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Narrow Lane and Tidal Flow Operations at Road Works on Motorways and Dual Carriageway Trunk Roads with Full Width Hard Shoulders

Summary: This Advice Note makes recommendations about techniques for increasing the throughout of traffic at road works on trunk road motorways and other dual carriageway trunk roads with full width (3.3 metres) hard shoulders.

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PART 3

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NARROW LANE AND TIDAL FLOW OPERATIONS AT ROAD WORKS ON MOTORWAYS AND DUAL CARRIAGEWAY TRUNK ROADS WITH FULL WIDTH HARD SHOULDERS

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1. INTRODUCTION

General

1.1 **This Advice Note must be read in conjunction with Chapter 8 of the Traffic Signs Manual (TSM) (Ref 1).** It is based on research carried out by the Transport Research Laboratory, Crowthorne, and reported on in Research Report No. 332 (Ref 2). Reference should also be made to "Planning for Safety" (Ref 3) and MHSWR 1992 (ref. 9).

1.2 Over the last decade, while traffic on all the United Kingdom's roads increased by about one third, that on the motorway system more than doubled. This unremitting rise in motorway use has implications for the maintenance of the network. The layout adopted at many major road works on 3-lane motorways is the contraflow. The capacity of a typical full contraflow system (2+2) is about 3450 vehicles/hour in each direction of travel. Nevertheless, traffic flows are so high at some sites that despite this high throughput severe delays will result at road works during peak periods unless extra capacity can be found. This Advice Note details techniques that have been developed to cope with the higher traffic demands.

1.3 This Advice Note deals with two ways of increasing the throughput:

- i Providing more lanes past the works area by reducing the width of the lanes.
- ii Making the direction of traffic in one lane reversible at sites where there is a marked daily change in the direction of the dominating flow.

European Community

1.4 The procurement of traffic signs will normally be carried out under contracts incorporating the Overseeing Organisation Specification for Highway Works (Manual of Contract Documents for Highway Works Volume 1). In such cases products conforming to equivalent standards and specifications of other member states of the European Economic Area and tests undertaken in other member states will be acceptable in accordance with the terms of the 104

and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition having the same effect regarding which advice should be sought.

Scope

1.5 The recommendations contained in this Advice Note cover the principles, operational characteristics and layouts for narrow lane systems and tidal flow operations associated with full and partial contraflow road works schemes on 2-lane and 3-lane trunk motorways and all-purpose dual carriageway trunk roads with continuous full width (3.3 metres) hard shoulders.

1.6 This Advice Note is based on motorways and roads with standard cross sections. Some carriageways may have additional width, and others, where the central reserve is paved, may also afford some marginal increase over the standard which could be used to provide wider traffic lanes. However, it would be necessary to ensure that any extended area of central reserve or hard shoulder paving is suitable for carrying traffic, particularly in the case of heavy goods vehicles (HGVs).

1.7 It is not practicable to illustrate every standard situation in the figures but the general principles are shown. Elements from two or more figures may be required to produce the needed design. In addition, if contraflow working is to be introduced on an all-purpose dual carriageway road then it will be necessary to take into account the interaction with pedestrians, and the proximity of other roads/accesses. Additional signs may be necessary, particularly in urban areas, to inform pedestrians of unusual or changed traffic movements. Engineers should consider if barriers should be used to restrict crossing points and if additional signing is necessary to warn pedestrians of changed traffic movements. If two way working has been introduced on a former one-way carriageway then 'PEDESTRIANS LOOK BOTH WAYS' signs will be a minimum additional requirement. Road markings should also be amended where appropriate and consideration should be given to the need for 'LOOK

LEFT' or 'LOOK RIGHT' markings to warn pedestrians that traffic may be approaching from an unexpected direction.

1.8 Siting distances (distances from datum) quoted in this document (Figures 2, 4, 6, 8 & 10) should be regarded as applicable in ideal situations. They may need to be varied to suit particular circumstances.

Definitions

1.9 primary carriageway -

the carriageway on which the road works are being carried out.

1.10 secondary carriageway -

the opposite carriageway to the one on which the road works are being carried out.

1.11 full contraflow -

a road works traffic management scheme where all of the traffic on both carriageways travels past the works area on the secondary carriageway.

1.12 partial contraflow -

a road works traffic management scheme where primary traffic flows past the works area on both the primary and secondary carriageways.

Implementation

1.13 This Advice Note adds to the choice of methods for traffic management at road works available in Chapter 8 of the Traffic Signs Manual (Ref 1). It should be taken into account forthwith for all schemes for major works on trunk motorways and all-purpose dual carriageway trunk roads with full width hard shoulders, including those currently being prepared or under construction provided that, in the opinion of the Overseeing Organisation, this would not result in unacceptable additional expense or delay. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. PRE-CONTRACT PLANNING

2.1 Traffic characteristics should be reviewed before narrow lane or tidal flow systems are employed. High proportions of commercial vehicles may preclude some layout designs where only one lane in each direction is allocated to vehicles wider than 6'-6" (wider vehicles). Traffic counts should be taken in each direction to record maximum flows.

2.2 A detailed survey of the highway will also need to be carried out in order to determine whether narrow lane or tidal flow techniques can be utilised. Precise carriageway widths will be needed, the carriageway edge condition assessed and the presence and strength of any hardening of the central reserve noted. Where the hard shoulder is to be used as a running lane a check should be made to ensure that no bridge or other structure protrudes on to it affecting the width available for traffic. The effects of any unevenness in the surface, such as the existence of drainage gullies, should also be considered. The hard shoulder should also be assessed for its ability to carry the expected traffic load and its camber noted - see paragraph 3.10 vi below.

2.3 The strength and skid resistance of the hard shoulder should be assessed before its use as a running lane - see paragraphs 2.3.14.3 & 2.3.14.4 of Volume 1 of Chapter 8 of the TSM (Ref 1).

2.4 It may be necessary to widen some carriageways in order to accommodate the lane widths given in Figure 1, or where HGV flows cannot be accommodated in one lane (see paragraph 3.7 below). The mandatory 50 mph speed limit at work sites would permit the required 1.2 m minimum clearance to the central reserve safety fence to be halved, releasing 0.6 m to the running lanes on sections where the paving is extended to the central reserve. Any extension carried out especially for this purpose should be strong enough to carry the expected traffic load and could be carried out as part of the preliminary works. Safety clearances between traffic and the works must be provided in accordance with section 2.5 of Volume 1 of Chapter 8 of the TSM (Ref. 1).

2.5 Recovery vehicles should be in attendance throughout the time a hard shoulder is being used as a running lane - see paragraph 2.3.14.8 of Volume 1 of Chapter 8 of the TSM (Ref 1).

2.6 Consideration should be given at the planning stage to how police escorted wide loads will be dealt with.

2.7 Any on-slips which may occur in a contraflow section will need to be very carefully designed as drivers on the main carriageway will have little room for manoeuvre. Consideration should be given to closing such on-slips where possible.

2.8 Where the hard shoulder is used as a running lane, the provision of hard-standing, temporary laybys (suitably signed) could encourage drivers of failing vehicles to stop off the travelled way. Consideration should be given at the planning stage to whether such provision would be possible.

2.9 Traffic Regulation Orders will be required to impose contraflow working, lane width restrictions and speed limits.

2.10 The provision of CCTV should be considered at the planning stage - see paragraph 5.4 below.

3. NARROW LANES

General

3.1 At contraflow sites, where the number of 'wider vehicles' allow (see paragraph 3.7 below), narrower traffic lanes can be used to enable more lanes to be provided past the works area. The normal motorway lane width is 3.65 m. Where heavy vehicles including public service vehicles, caravans, etc are expected the lane width may only be reduced to 3.25 m, desirable minimum, and where there is a shortage of space an absolute minimum of 3.0 m. However, where the traffic is expected to consist only of cars and other light vehicles the lane width may be reduced to 2.75 m (desirable minimum) or 2.5 m (absolute minimum).

3.2 Narrow lane contraflows require a raised level of driver concentration and this should be taken into consideration when determining the maximum length of the scheme - see also Chapter 8 of the TSM (Ref 1), Table F.

3.3 With narrow lanes, good alignment is critical and it is essential that transitions or crossovers are designed to an acceptable design speed - see paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) and TD9 (Ref 4).

3.4 Mandatory speed limits of 50 mph shall be imposed on all narrow lane schemes in accordance with Section 2.3.4 of Volume 1 of Chapter 8 of the TSM (Ref 1).

3.5 Consideration must be given to the safety of cyclists when narrow lane techniques are applied on all-purpose roads. It is particularly important in the case of partial contraflow schemes (such as in Figure 3) to ensure that the single lane, situated on the primary carriageway, is of adequate width to allow 'wider vehicles' to pass cyclists.

3.6 The mandatory 50 mph speed limit at work sites would permit the required 1.2 m minimum clearance to the central reserve safety fence to be halved, releasing 0.6 m to the running lanes on sections where the paving is extended to the central reserve. Any extension carried out especially for this purpose should be strong enough to carry the expected traffic load and could be carried out as part of the preliminary works. Safety clearances between traffic and the works must be provided in accordance with section 2.5 of Volume 1 of Chapter 8 of the TSM (Ref 1).

3.7 The operation of a layout based on the lane widths shown in either Figure 1 or Figure 3 is limited by the number of 'wider vehicles' using the road, since there is only one lane available in each direction suitable for them. Calculations based on local flow characteristics should be carried out to ascertain the ability to carry anticipated 'wider vehicle' flows before utilisation of this method. In the absence of such data guidance may be given from paragraph 4.4.3.2 of Chapter 8 of the TSM (Ref 1). i.e. a maximum flow of 850 HGV's per hour per lane. Where one lane is insufficient to carry the number of 'wider vehicles' using the site, it may be possible to provide a second 3.0 m wide lane if the carriageway will accommodate this or can be widened to do so.

3-lane Carriageways - Full Contraflow

3.8 Full contraflow systems on 3-lane carriageways, such as is shown in layout 33 of Volume 2 of Chapter 8 of the TSM (Ref 1), can be extended by completely removing the existing markings from the secondary carriageway and remarking it into five reduced width lanes - see Section 3.3 of Volume 1 of Chapter 8 of the TSM (Ref 1) for temporary road markings and studs. Figure 1 gives the layout and minimum acceptable lane widths through the contraflow section - see paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) regarding the design of crossovers. It may be necessary to widen some carriageways in order to accommodate the lane widths given in Figure 1 - see paragraph 3.6 above. The lanes of 2.5 m and 2.7 m in width should be increased to 2.75 m wide wherever possible.

3.9 The system illustrated in Figure 1 tends to even out the disruption to the traffic on the two carriageways. However, it may be necessary to change the lane allocations (ie. restrict the 'primary' traffic to two lanes and allow the full three lanes for the 'secondary' traffic) where, say, there is an adverse imbalance in directional flows during peak periods, or because of the presence of slow moving vehicles travelling up an incline.

3.10 The following matters should be considered when designing a scheme based on the layout shown in Figure 1:

- i. The overall width of the contraflow buffer zone may be reduced from 1.2 m to 0.9 m (see

APPENDIX A), but 1.2 m should be used where width permits and desirable minimum lane widths have been accommodated (see paragraph 3.1 above).

ii. To avoid driver confusion it is essential that all original road markings are thoroughly removed, especially the hard shoulder/lane 1 continuous marking, before the carriageway is remarked to the new configuration.

iii. The lane delineation markings should be to diagram 1004 (6 m mark, 3 m gap) of The Traffic Signs Regulations (The Regulations) (Ref 5) instead of the conventional marking of 2 m mark, 7 m gap (diagram 1005).

iv. Ideally there should be no difference in the surface characteristics between any parts of the carriageway. The reconfiguration of the carriageway may place the longitudinal joints or the original road stud bases within the new lanes and in some cases in line with the vehicle wheeltracks. It is recommended that the road stud bases, as well as the rubbers and their reflectors, are removed and the carriageway reinstated before introducing traffic to the narrow lane layout. If stud bases are retained, drivers may take avoiding action and, in addition, the bases may be held unlawful because they are not fitted to statutorily prescribed line markings.

v. The carriageway edge condition should be considered when running on the hard shoulder. Allowance should be made for the presence of kerbing, since this will have the effect of reducing the running lane width as passing traffic shies away. Fixtures, such as emergency telephones may also be closer to the edge of the hard shoulder than desirable when it is being used as a running lane. Drainage facilities on the verge can also give rise to problems if the filter medium is loose, or if there is a dished drainage channel adjacent to the edge of a trafficked lane. Reference should be made to paragraphs 6.4 & 6.5 below with regard to marking the carriageway edge.

vi. The hard shoulder should be continuous, have adequate headroom and be sufficiently strong to carry the expected traffic load, also any significant adverse camber that it may have should be eliminated. It may be that on curves of older motorways, whilst the carriageways drain to the centre, the runoff from the hard shoulder is to the nearside; on more recent links, drainage is uniform. When hard shoulders are used as running lanes practitioners should comply with the

advice given in Section 2.3.14 of Volume 1 of Chapter 8 of the TSM (Ref 1).

3.11 The layout for the signing of a full contraflow narrow lane scheme on a 3-lane motorway/dual carriageway with full width hard shoulders, is given in Figure 2. Refer to 'KEY TO SYMBOLS' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) for the details indicated by capital letters in the Figure.

3-lane Carriageways - Partial Contraflow

3.12 Partial contraflow systems on 3-lane carriageways, such as is shown in layout 32 of Volume 2 of Chapter 8 of the TSM (Ref 1), can be extended by completely removing the existing markings from the secondary carriageway and remarking it into five reduced width lanes - see Section 3.3 of Volume 1 of Chapter 8 of the TSM (Ref 1) for temporary road markings and studs. The layout and lane widths through the contraflow section should be as shown in Figure 3, but the lanes of 2.5 m and 2.7 m in width should be increased to 2.75 m wide wherever possible. See paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) regarding the design of crossovers.

3.13 Paragraphs 3.10 i to vi above also apply to schemes based on the layout in Figure 3.

3.14 The layout for the signing of a partial contraflow narrow lane scheme on a 3-lane motorway/dual carriageway with full width hard shoulders, is given in Figure 4. Refer to 'KEY TO SYMBOLS' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) for the details indicated by capital letters in the Figure.

2-lane Carriageways - Full Contraflow

3.15 It is not possible to increase the number of traffic lanes past the works area by narrowing the width of the lanes of a full contraflow system on a standard 2-lane carriageway.

2-lane Carriageways - Partial Contraflow

3.16 Partial contraflow is not normally operated on 2-lane carriageways and will not be considered here.

4. TIDAL FLOW (REVERSIBLE FLOW) LANES

General

4.1 At sites where there is a marked daily change in the direction of the dominating flow, contraflow schemes can be modified to permit tidal flow operation. Under this system, additional lanes are run in the direction of the higher flow, at the expense of the other (less trafficked) direction, reversing as necessary the configuration to accommodate changes in the balance of flows.

4.2 Mandatory speed limits of 50 mph shall be imposed on all tidal flow schemes in accordance with Section 2.3.4 of Volume 1 of Chapter 8 of the TSM (Ref 1).

2-lane Carriageways - Full Contraflow

4.3 Full contraflow systems on 2-lane carriageways, such as is shown in layout 21 of Volume 2 of Chapter 8 of the TSM (Ref 1), can be modified for tidal flow and this allows some flexibility in operation over the current static configuration. The layouts and lane widths through the contraflow section should be as shown in Figure 5. See paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) regarding the design of crossovers.

4.4 Paragraphs 3.10 i, iv, v and vi above also apply to schemes based on the layout in Figure 5.

4.5 Figure 5(a) illustrates the basic concepts of the full contraflow tidal system. Approaching traffic is marshalled into physically divided lanes, which then guide the vehicles through the contraflow. Access to the tidal lane is controlled by four 'gates', which are at key locations as shown in Figure 5(a). Each 'gate' is formed by a line of traffic cones, at approximately 1.2 m centres and, at the gates at which there is a reduction in traffic lanes, there shall also be three "lane closed" signs to diagram 569.1 (7105) of The Regulations (Ref 5), each surmounted by a "Keep left" sign to diagram 610, as illustrated towards the top of the 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1). The two operating conditions shown in Figure 5(a) are summarised below. In the Figure a convention is adopted that a gate is "open" if it lies

parallel to the carriageway lane lines, and "closed" when it is drawn at an angle across the lane.

4.6 **Condition 1+2:** As with the conventional contraflow layout, traffic on the primary approach is diverted to the hard shoulder and lane 1. The right hand lane at the splitter island is now closed by a cone taper (gate 1), which channels the approaching traffic into a single lane, running along the hard shoulder. This single traffic lane is carried across the central reserve to run along the contraflow on lane 2 of the secondary carriageway. The return is accomplished using the left hand lane of the two-lane crossover, before restrictions are lifted and the traffic reverts to normal running. In the opposite direction, a lane 2 closure directs traffic to run on the hard shoulder and lane 1. Traffic in lane 1 is separated from that on the hard shoulder by a splitter island (gate 4, open), and runs through the contraflow contiguous with, but physically separated from, the hard shoulder (gates 2 and 3, open). At the end of the works the restrictions on lane 1 are removed, traffic on the hard shoulder regains the main carriageway and normal motorway operating conditions apply.

4.7 **Condition 2+1:** As previously, traffic on the primary approach is transferred to run on the hard shoulder and lane 1. The two lanes are run either side of a splitter island (gate 1, open), channelling the traffic into two contiguous, but physically separate lanes. These are carried together across the central reserve, using a variant of the two-lane crossover to run on lanes 1 and 2 of the secondary carriageway (gates 2 and 3, closed). A second two-lane crossover returns the traffic to the primary carriageway, where the delineator between the two lanes is removed and traffic reverts to normal operation. On the secondary approach, the two-lane traffic is initially transferred to the hard shoulder and lane 1 before reduction (gate 4, closed) to single lane running on the hard shoulder to run through the contraflow. At the end of the works, vehicles are returned once more to the main carriageway (lane 1), before resuming normal two-lane operation.

4.8 The layout for the signing of a full contraflow tidal flow scheme on a 2-lane motorway/dual carriageway with full width hard shoulders, is given in Figure 6. Refer to 'KEY TO SYMBOLS' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) for the details indicated by capital letters in the Figure.

2-lane Carriageways - Partial Contraflow

4.9 As mentioned at paragraph 3.16 above, partial contraflow is not normally operated on 2-lane carriageways. Therefore, tidal flow on such a

configuration will not be considered here.

3-lane Carriageways - Full Contraflow

4.10 Full contraflow systems on 3-lane carriageways, such as is shown in layout 33 of Volume 2 of Chapter 8 of the TSM (Ref 1), can be modified for tidal flow, but there is a limitation to the use of this system. This arises from the match between lane allocation (1+3 and 2+2) and the peak demand pattern. Only about 5 per cent of motorways have a marked imbalance (ie a ratio of 70/30 or higher) in their directional flows during individual peak periods. In contrast, around 50 per cent of them display tidalities greater than 60/40.

4.11 The layouts and lane widths through the contraflow section of a full contraflow tidal flow system on a 3-lane carriageway should be as shown in Figure 7. See paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) regarding the design of crossovers. Tidal flow is achieved in a similar manner to that indicated in paragraphs 4.5 to 4.7 above.

4.12 Paragraphs 3.10 i, iv, v and vi above also apply to schemes based on the layout in Figure 7.

4.13 The layout for the signing of a full contraflow tidal flow scheme on a 3-lane motorway/dual carriageway with full width hard shoulders, is given in Figure 8. Refer to 'KEY TO SYMBOLS' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) for details indicated by capital letters in the Figure.

3-lane Carriageways - Full Contraflow Using Narrow Lanes

4.14 The addition of a second buffer zone to the full contraflow narrow lane layout shown in Figure 1, places a severe constraint on the lane widths. For a standard carriageway the lane widths would have to be less than the absolute minimum dimensions given in paragraph 3.1 above and so this option is not considered here.

3-lane Carriageways - Partial Contraflow

4.15 Partial contraflow systems on 3-lane carriageways, such as is shown in layout 32 of Volume 2 of Chapter 8 of the TSM (Ref 1), can be modified for tidal flow and this offers two lanes in each

direction, plus a reversible lane to maintain three lanes in the peak direction. This offers a variable 3/2 lane split, mirroring the typical 60/40 motorway tidality.

4.16 The layouts and lane widths through the contraflow section of a partial contraflow tidal flow system on a 3-lane carriageway should be as shown in Figure 9 - see paragraph 4.4.2.1 of Volume 1 of Chapter 8 of the TSM (Ref 1) regarding the design of crossovers. The Figure illustrates the non-contraflow lane being on the hard shoulder of the primary carriageway, but it could be positioned on any of the traffic lanes. All lanes are over 3m wide, which would permit allocation of an additional lane to 'wider vehicles' if required. Tidal flow is achieved in a similar manner to that indicated in paragraphs 4.5 to 4.7 above.

4.17 Paragraphs 3.10 i, iv, v and vi above also apply to schemes based on the layout in Figure 9.

4.18 The layout for the signing of a partial contraflow tidal flow system on a 3-lane motorway/dual carriageway with full width hard shoulders, is given in Figure 10. Refer to 'KEY TO SYMBOLS' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) for the details indicated by capital letters in the Figure.

5. OPERATIONAL CHARACTERISTICS OF NARROW LANE AND TIDAL FLOW OPERATIONS

Vehicle Throughput

5.1 Maclean & Greenway (1977)(Ref 6) found that vehicle throughput on narrow lanes was about 15 per cent lower than the lane capacity at conventional work sites. However, more recent observations at two narrow lane road works sites indicate only a small reduction and suggest that lanes of width less than 3.0 m have an operational capacity of between 1700 and 1800 veh/h with flows of up to 10 per cent higher at sites where commuting traffic predominates. Observations of "normal" flow characteristics at a site prior to the introduction of road works may be of assistance in predicting capacity during the works period.

Incident Procedures

5.2 It is essential to have an efficient recovery service and a well defined operational procedure in the event of an incident. Recovery vehicles should be present on site throughout the period of hard shoulder usage, and located on the approach to the works, perhaps on a prepared dedicated strip behind the hard shoulder, to enable a swift response to incidents - see paragraph 2.3.14.8 of Volume 1 of Chapter 8 of the TSM (Ref 1). They shall be operated by trained and experienced staff.

5.3 A tidal layout with its bounded single lane is particularly vulnerable in the event of an incident. However, in an emergency the tidal lane could be closed and cleared, either to assist access by the services to the incident, or for operation in the reverse direction should an incident cause a blockage on the opposing lane(s). The tidal lane normally has sufficient latitude to carry mixed traffic in these circumstances, and may be used to redirect traffic to bypass the obstruction. At night when traffic flows are low, the tidal lane may be closed, to serve as a buffer lane between opposing flows and for maintenance and emergency access. Consideration could also be given to the closure of the tidal lane in off-peak periods if flows permit.

5.4 At any major layout, good communications and effective surveillance are essential to coordinate recovery and emergency services, and reduce the

incident duration. The use of closed circuit television (CCTV) to monitor road works is becoming more common and should be considered at the planning stage. If provided, CCTV should be monitored continuously. To be effective the camera locations need to be carefully selected to ensure comprehensive coverage both through the contraflow and on the approaches. The control centre should be in the site compound if possible, and serve as the main communications link to Recovery, Contractor's and Resident Engineer's staff and the emergency services. The operatives should be well trained and appreciate the key role which they play in ensuring the smooth operation of the layout. CCTV facilities can be particularly useful in providing accurate reports to the motoring organisations, police and local radio stations on any traffic problems during peak periods.

Emergency Route

5.5 At full contraflow schemes, such as those shown in Figures 1, 5 & 7, a continuous and unobstructed emergency route, which is available for use at all times, shall be provided through the works site.

Traffic Characteristics

5.6 Traffic characteristics should be reviewed before these systems are employed. High proportions of commercial vehicles may preclude some layout designs where only one lane in each direction is allocated to 'wider vehicles'. (See paragraph 3.7 above).

Installation Procedure

5.7 Consideration needs to be given to the installation procedure. Due in part to the additional buffer zone, tidal flow layouts take longer to set out (and to change phases) than conventional systems. Given the amount of equipment to install and the requirement that the layout cannot be left in an unsafe temporary configuration, the feasibility of installation should be addressed at the design stage of the scheme.

This would need to take account of the traffic flows and windows of opportunity. In order to complete the main installation overnight with a margin for delays, the road studs delineating the buffer zones may be installed the previous night. (See also ref 8).

5.8 Operatives who install contraflow schemes and effect tidal flow changeovers (see paragraph 5.10 below) should be fully trained in the safety procedures to adopt on high speed roads and the discipline necessary to work in a team. It is essential to have a consistent skilled team available for these tasks.

Tidal Flow Changeover

5.9 During the design stage, it is essential to determine the tidality of the traffic flow, not only to be able to predict the effectiveness of the proposed traffic management system, but also to determine the time when the lanes should be changed. The time of change may have to be different at weekends and bank holidays; timings should be reviewed in the first days of operation. In common with the narrow lane layout, these systems involve a large quantity of traffic management equipment, and need careful planning and time to set out.

5.10 The changeover procedure for a tidal flow scheme should be planned so that it does not cause confusion to approaching drivers. It requires the close coordination of the operating staff. It is essential for safety that operatives work systematically through the site. Initially, the advance signs on one approach should be changed prior to closing the tidal lane gate. The closure of this lane would then offer the opportunity to maintain the delineators (ie cones, cylinders, etc) as the team progress through the site, changing the direction arrow boards and switching the intermediate gates at the crossovers. The tidal lane gate at the far end should then be opened and the signing on that approach then changed to indicate the new configuration. Prior to opening the gate at the far end an opportunity exists for an extended closure of the tidal lane if required - see paragraph 5.3 above.

5.11 Changeovers can be successfully carried out by a small, competent, well briefed, consistent team of about five people, with the team leader checking each stage. However, there is always an element of danger in crossing the carriageway and two teams, one on the off-side of the carriageway and the other on the near-side, working in synchronism, could reduce the need to cross and re-cross running lanes during changeovers.

Consideration should be given at the design stage to the practicality of installing a signing system where the legends of signs that need to be changed can be operated electronically.

Maintenance of Buffer Zones

5.12 It may be necessary to close the off-side lane in both directions to enable maintenance of the buffer zone. Such closures will need to commence prior to the contraflow section to enable the provision of adequate advance warning to drivers. If closures were to commence in the contraflow section then the off-side advance signs would have to be placed on the opposite side of the opposing traffic flow where it is unlikely that they would be noticed or considered relevant.

6. SIGNING

6.1 The signs used should comply with the Signing Schedule and be as illustrated in the Figures. Vehicle width limits should be given in Imperial units as 6'-6".

6.2 Where a junction is within the works area and segregation of traffic by destination is required, the advance signs and those indicating a bifurcation of routes to different destinations, should be designed in accordance with Diagrams 1 to 4.

6.3 Where opposing lanes of traffic are separated by a buffer zone, signs should be provided at 1/2 mile intervals to indicate the existence of the adjacent opposing lane, any prohibitory roundels where required and a bottom plate giving the remaining distance of the contraflow. An exception to this is where a hard shoulder is used as a running lane and the continuous edge of carriageway/hard shoulder road marking can be seen by drivers. In this case the edge of carriageway/hard shoulder line should be illustrated on the signs which should then be repeated at 1/4 mile intervals. The opposing lane(s) of traffic should be indicated on the signs by a single reverse arrow in outline - since the opposing flow is segregated by the buffer zone it is represented by only one of these arrows irrespective of the number of opposing lanes of traffic.

6.4 Where a hard shoulder is used as a running lane its edge should be marked as given in paragraph 3.3.7 of Volume 1 of Chapter 8 of the TSM (Ref 1). In addition, where a French/filter drain or other soft material is adjacent to the edge of the hard shoulder, traffic cones should be placed on top of the filter/soft material with their bases touching the edge of the hard shoulder and spaced at approximately 18 metre intervals.

6.5 An edge line and traffic cones, as given in 6.4 above, should also be provided when there is a dished drainage channel adjacent to the edge of a trafficked lane.

6.6 The need for signing and guarding for pedestrians should be assessed where a contraflow is to be introduced on an all-purpose dual carriageway road, particularly in an urban area - see paragraph 1.7 above.

6.7 Each 'gate' used in a tidal flow scheme shall consist of a row of traffic cones at approximately 1.2 m

centres. At the gates where there is a reduction in traffic lanes, there shall also be three "lane closed" signs to diagram 569.1 (7105) of The Regulations (Ref 5), each surmounted by a "keep left" sign to diagram 610, as illustrated towards the top of the 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the TSM (Ref 1) - see also paragraph 4.5 above.

7. COST BENEFITS OF THE SYSTEMS

7.1 An indication of the potential benefits which may accrue from these innovative systems, compared with the conventional full and partial contraflow layout, was obtained using the economic evaluation program QUADRO 2 (Ref 7). For each type of layout, the basic parameters were fixed, varying only the number of available lanes and their capacity. The narrow lane systems were represented by reducing the standard lane capacity by 15 per cent, while the tidal systems were modelled by varying the configuration of lanes by time of day and operating more lanes in the peak direction. Estimates were made for the additional direct costs associated with the new layouts, such as the supplementary expenditure arising from the signing and markings, and labour costs to switch the tidal layout.

7.2 These direct cost estimates were offset against the QUADRO 2 user costs to give estimates for the total (ie direct and indirect) cost implications of each type of layout. Figure 11 shows these cost estimates as a percentage of the costs associated with the conventional (2+2) full contraflow layout, for a total daily demand flow of 90,000 vehicles.

7.3 At this level of daily flow, the five-lane narrow lane layout showed savings of about 15 per cent over the conventional full contraflow system. There can also be substantial savings with the tidal system when the layout configuration matches the prevailing traffic tidality at the site.

7.4 Additional benefits are achievable by the application of these new designs to the partial contraflow, despite the cost penalty of running traffic on the work's carriageway. The tidal derivative of this layout offers a variable 3/2 lane split, mirroring the typical 60/40 motorway tidality, and potentially offers a 50 per cent saving over the conventional full contraflow costs. The greatest improvement may be achieved from a partial contraflow using three fixed lanes in each direction, though, as noted in paragraph 3.16 above, its general applicability may be limited by the provision of only one lane each way to accommodate 'wider vehicles'.

8. REFERENCES

1. The Traffic Signs Manual Chapter 8 (1991 edition) - Traffic Safety Measures and Signs for Road Works and Temporary Situations - HMSO.
2. Department of Transport, TRL Research Report No. 332 - Modified Contra-flow Layouts for Major Maintenance: Narrow Lane and Tidal Flow Operations, by M Marlow, G A Coe and R Evans (1992) - Transport Research Laboratory, Crowthorne.
3. Guidance note "Planning for Safety" by The Department of Transport, The Welsh Office, The Federation of Civil Engineering Contractors and The Scottish Office Industry Department (1992) - FCEC.
4. Standard TD9 - Highway Link Design (DMRB 6.1.1) - HMSO.
5. The Traffic Signs Regulations and General Directions 1981 (SI 1981 No 859) as amended, also The Traffic Signs Regulations (NI) 1979 (SR 1979 No 386) as amended - HMSO.
6. Department of Transport, TRRL Report LR 782 - Crawler Lane Construction on M5: the Use of Narrow Lanes by A D Maclean and M Greenway (1977) - Transport Research Laboratory, Crowthorne.
7. Department of Transport computer program QUADRO 2 for the Economic Evaluation of Road Schemes.
8. Department of Transport/County Surveyors Society, Safety at Roadworks, Notes for Guidance - 1994.
9. Management of Health and Safety at Work Regulations 1992. (MHSWR)

9. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

Head of Network General and Maintenance
Division
The Highways Agency
St Christopher House
Southwark Street
London
SE1 OTE

C DIXON
Head of Network General
and Maintenance Division

The Deputy Chief Engineer
The Scottish Office Industry Department
Roads Directorate
New St Andrew's House
Edinburgh EH1 3TG

J INNES
Deputy Chief Engineer

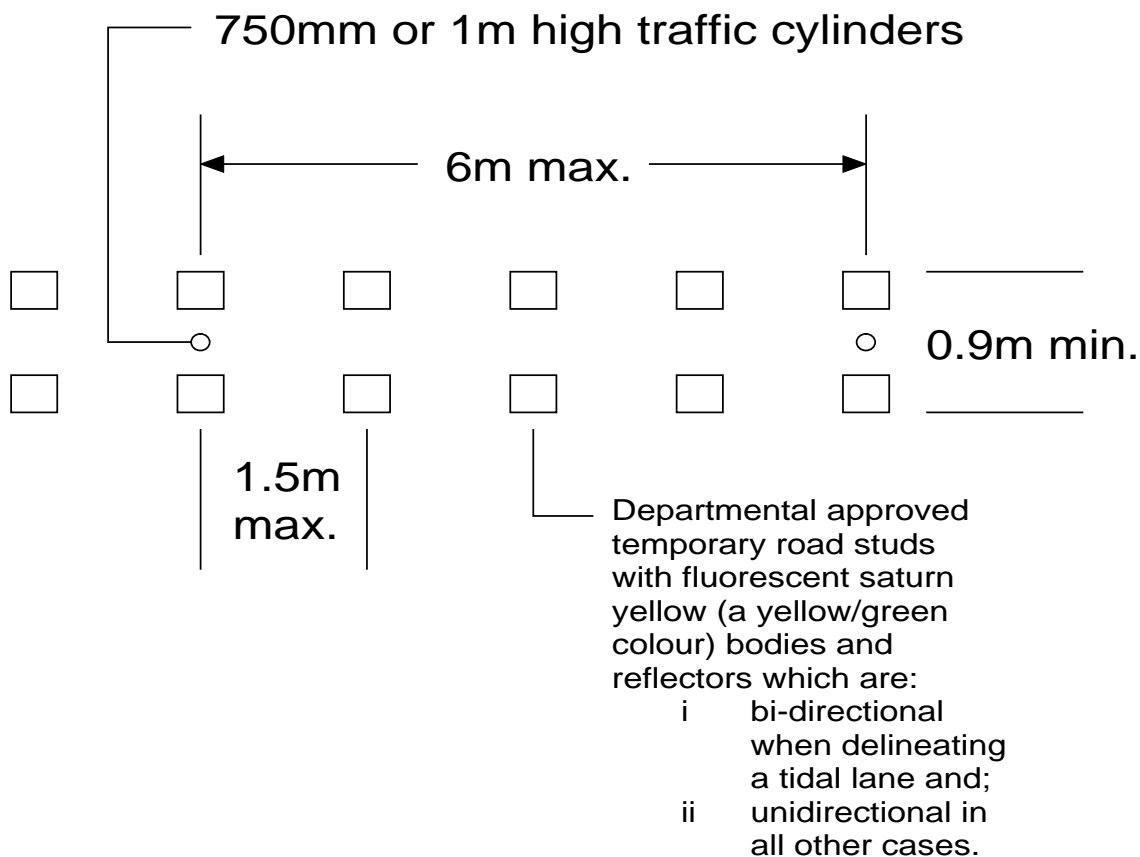
Head of Roads Engineering (Construction) Division
Welsh Office
Y Swyddfa Gymreig
Government Buildings
Ty Glas Road
Llanishen
Cardiff CF4 5PL

B H HAWKER
Head of Roads Engineering
(Construction) Division

Assistant Chief Engineer (Works)
Department of the Environment for
Northern Ireland
Roads Service Headquarters
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

D O'HAGAN
Assistant Chief Engineer (Works)

DETAILS OF CONTRAFLOW BUFFER ZONE



NOTES:

1. Bi-directional reflectors shall be red on the near-side of approaching traffic and amber on the off-side. Unidirectional reflectors shall be amber.
2. The cylinders may be off-set within the buffer zone to utilise existing road stud bases.

Details of contraflow buffer zone

SIGNING SCHEDULE

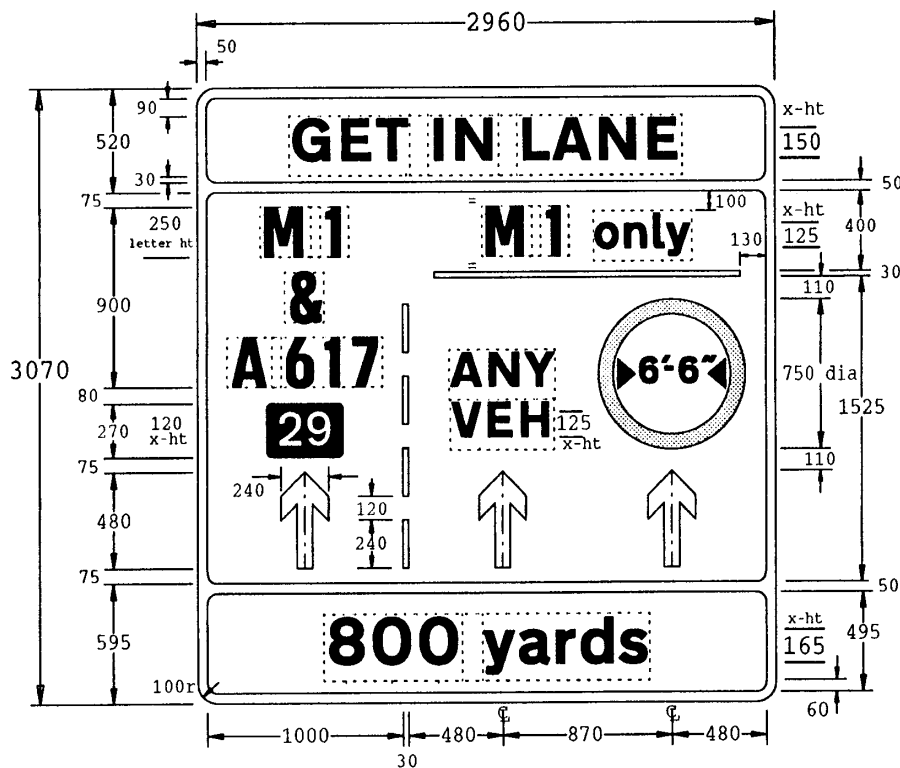
SIGNING SCHEDULE		Proposed sign diagram numbers (drawing Nos. prefixed by 'P')		
Sign No. given on Figures	Existing sign drawing numbers	Top panel	Main sign No. and panels for main sign	Bottom panel or plate
1	WBM338.1		7004	
2	WM564,571		7001	572
3	WBM338		7005	
4	NP401		7290	
5	WBM952.1,.3 & 950.2 & 951.1	7262	7201, 7281, 7283	7271
6	WBM283.4 & 951.1,.4	7264	7235, 7281, 7283	7271
7	WBM956.6		7306	
8	WM610 + Amber flashing beacon		610 + Amber flashing beacon	
9	WM565.2		7301	
10	WBM952.1,.3 & 951.4	7264	7201, 7281, 7283	
11	WBM277 & 952.1, .3 & 950.3	7263	7210, 7281, 7283	
12	WBM952.1,.3,.8 & 951.3,.4	7264	7201, 7281, 7283 & 7288	7273
13	WBM278 & 952.1, .2 & 950.3	7263	7215, 7281, 7283	
14	WBM339		7006	
15	WM564 & 645		7001	645
16	WBM952.1,.3,.7 & 950.2 & 951.1	7262	7201, 7281, 7283 & 7287	7271
17	WBM952.1,.3,.7 & 951.1		7201, 7281, 7283 & 7287	7271
18	WM1014		1014	
19	WBM283 & 952.1, .3 & 951.1,.4	7264	7230, 7281, 7283	7271

Appendix B

SIGNING SCHEDULE		Proposed sign diagram numbers (drawing Nos. prefixed by 'P')		
Sign No. given on Figures	Existing sign drawing numbers	Top panel	Main sign No. and panels for main sign	Bottom panel or plate
20	WBM283 & 952.1, .3 & 950	7260	7230, 7281, 7283	
21	WBM283.1 & 950.1	7261	7231	
22	WM610		610	
23	WBM277.2 & 952.1,.3 & 951.4	7264	7212, 7281, 7283	
24	WBM952.3,.8 & 951.3,.4	7264	7201, 7283, 7288	7273
25	WBM278		7215	
26	WBM283 & 950.3 & 951.1	7263	7230, 7281, 7283	7271
27	WBM952 & 952.7 & 951.1		7207	7208
28	WBM283.7 & 950.3 & 951.1	7263	7238, 7281, 7283	7271
29	WM1041		1041	
30	WM611		611	
31	WBM277		7210	
32	WBM952 & 952.8 & 951.3		7203	7209
33	WBM952 & 952.8 & 951.3		7203.1	7209
34	WBM283.1 & 950.1	7261	7232	
35	WM1011		1012.1 (100mm width)	
36	WBM283.7 & 950.3 & 952.1,.3	7263	7238, 7281, 7283	
37	WBM277.2		7212	
38	WBM858.3 & 951.3		7204	7209
39	WBM952 & 952.7 & 951.1		7202	7208

DIAGRAMS 1, 2, 3 & 4

DIAGRAM 1



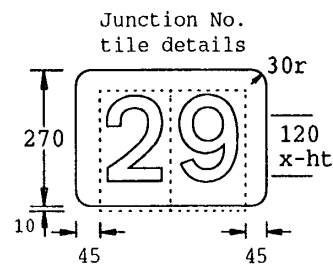
- NOTES: 1. Legends are from the Transport Heavy alphabet and Motorway black temporary alphabet at the x-heights shown. Junction No. from the Transport Medium alphabet.
2. The outlines of the tiles do not form part of the sign.

3.Colours: BS.873:Part 6 (Black & White- Table 5
Other colours- Clause 4.3.3)

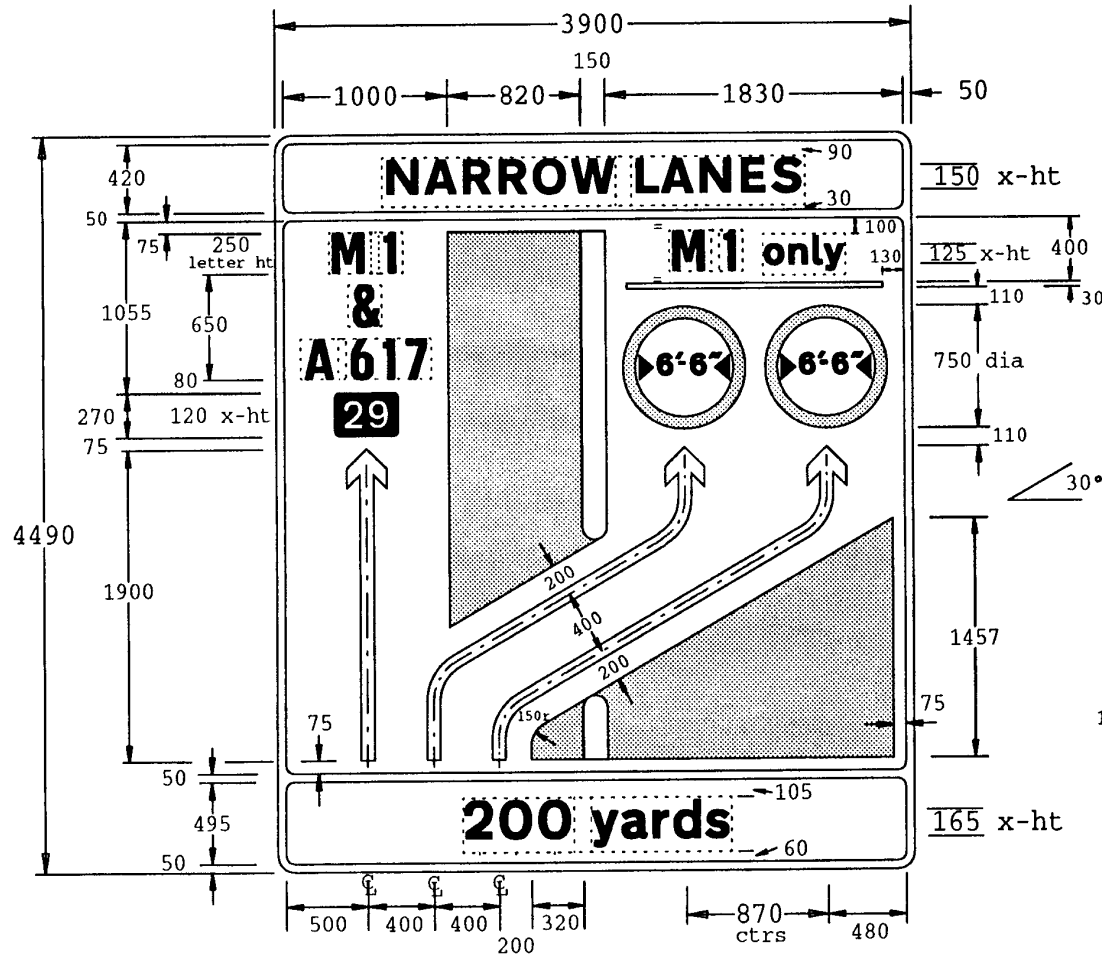
Background----- YELLOW
Borders,Legends,Arrows,
Background to Junction No.
and Symbols----- BLACK
Roundel----- RED
Roundel interior
and Junction No.----- WHITE

4. Illumination: This shall comply with Section 2.4 of Volume 1 of Chapter 8 of the Traffic Signs Manual (Ref 1).

5. The sign shall comply with the current edition of BS.873.



ALL DIMENSIONS ARE IN MILLIMETRES

DIAGRAM 2

NOTES: 1. Legends are from the Transport Heavy alphabet and Motorway black temporary alphabet at the x-heights shown. Junction No. from Transport Medium alphabet.

2. Tile outlines are not part of the sign.

3. Colours: BS.873:Part 6

(Black & White- Table 5
Other colours- Clause 4.3.3)

Background----- YELLOW

Borders,Legends,Arrows,
Background to Junction No.

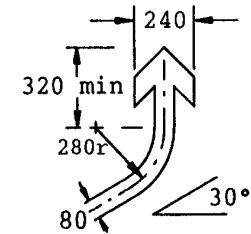
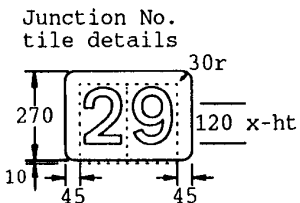
and Symbols----- BLACK

Roundels and
shaded work areas----- RED

Roundel interior
and Junction No.----- WHITE

4. Illumination: This shall comply with Section 2.4 of Volume 1 of Chapter 8 of the Traffic Signs Manual (Ref 1).

5. The sign shall comply with the current edition of BS.873.



ALL DIMENSIONS ARE IN MILLIMETRES

DIAGRAM 3

The main diagram shows a rectangular traffic sign with overall dimensions of 2850 mm width and 3800 mm height. It is divided into a top panel (2785 mm high) and a bottom panel (545 mm high). The top panel contains the text 'GET IN LANE' at the top, followed by 'M1 & A42 23A' on the left and 'M1 only' on the right, with a large shaded rectangular area on the right. The bottom panel contains the text '800 yards'. Dimensions for text height (x-ht) are given as 150 for 'GET IN LANE', 125 for 'M1 & A42 23A' and 'M1 only', and 165 for '800 yards'. A detailed view of the 'Junction No. tile details' shows a rectangular tile with dimensions 270 mm height and 120 mm width, with a 30r radius on the top right and 45 mm side margins. A side view shows the sign's profile with a 30° angle and a minimum height of 320 mm for the arrow and text area.

NOTES: 1. Legends are from the Transport Heavy alphabet and Motorway black temporary alphabet at the x-heights shown. Junction No. from Transport Medium alphabet.

2. Tile outlines are not part of the sign.

3. Colours: BS.873:Part 6
(Black & White- Table 5
Other colours- Clause 4.3.3)

Background----- YELLOW
Borders,Legends, Arrows,
Background to Junction No.
and Symbols----- BLACK
Shaded work areas----- RED
Junction No.----- WHITE

4. Illumination: This shall comply with Section 2.4 of Volume 1 of Chapter 8 of the Traffic Signs Manual (Ref 1).

5. The sign shall comply with the current edition of BS.873.

This diagram provides a detailed view of the junction number tile. It is a rectangle with a height of 270 mm and a width of 120 mm. The junction number '23A' is centered within the tile. The top right corner of the tile has a 30r (30 mm radius) fillet. There are 45 mm margins on the left and right sides of the tile.

This diagram shows the arrow and junction details. The arrow is a white arrow on a black background, pointing upwards and then curving to the right. The arrow has a minimum height of 320 mm and a width of 240 mm at the top. The junction is marked with a 30° angle and a 280r (280 mm radius) fillet. The arrow has a width of 80 mm at the bottom.

ALL DIMENSIONS ARE IN MILLIMETRES

ALL DIMENSIONS ARE IN MILLIMETRES

TOP PANEL
see P 7260

2300

100r

150 x-ht

770

75

250
letter
ht

80

270

75

2905

2135

50

125 x-ht

75

970

30

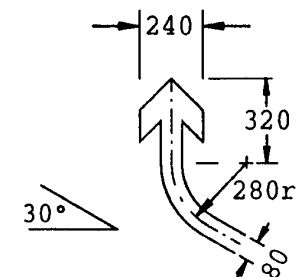
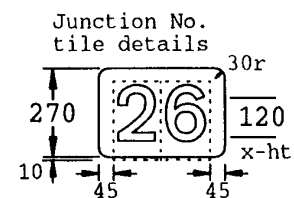
L/4

L/2

L/4

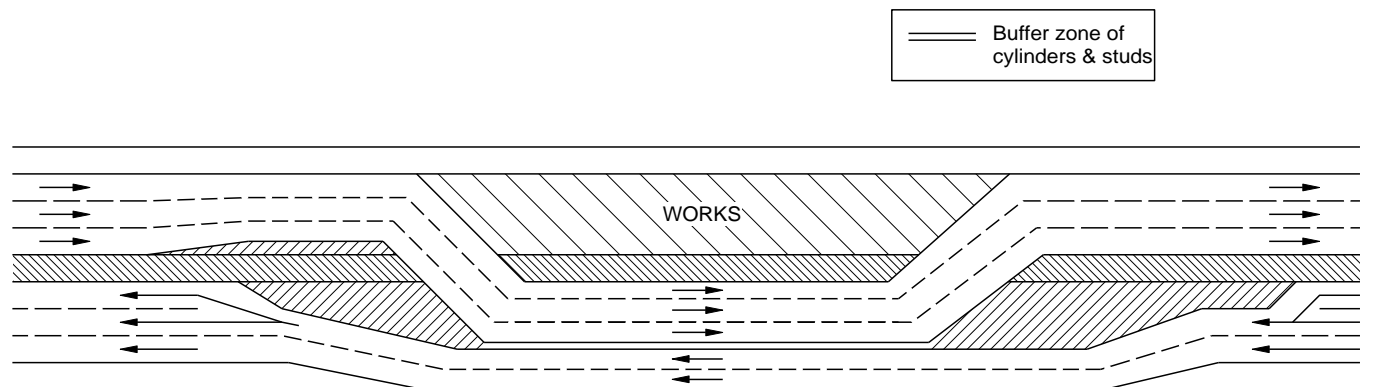
L

5. The sign shall comply with the current edition of BS.873.



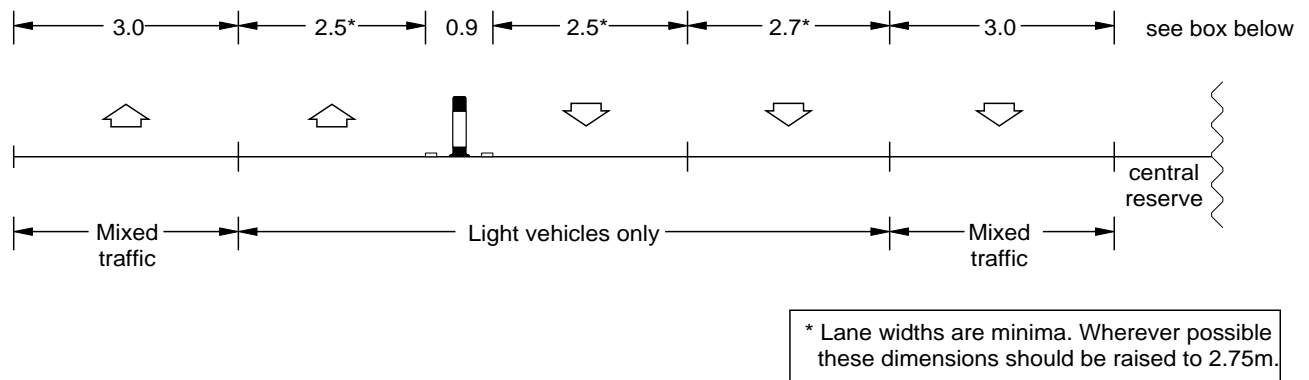
ALL DIMENSIONS ARE IN MILLIMETRES

FIGURES 1, 3, 5, 7 & 9



a) Schematic layout

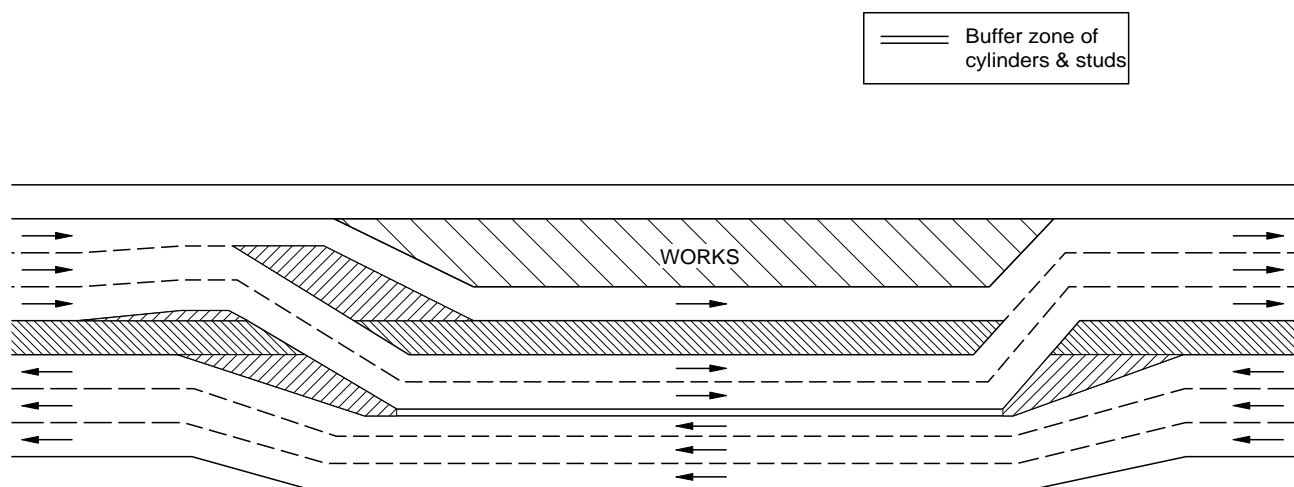
All dimensions in metres



b) Carriageway cross section

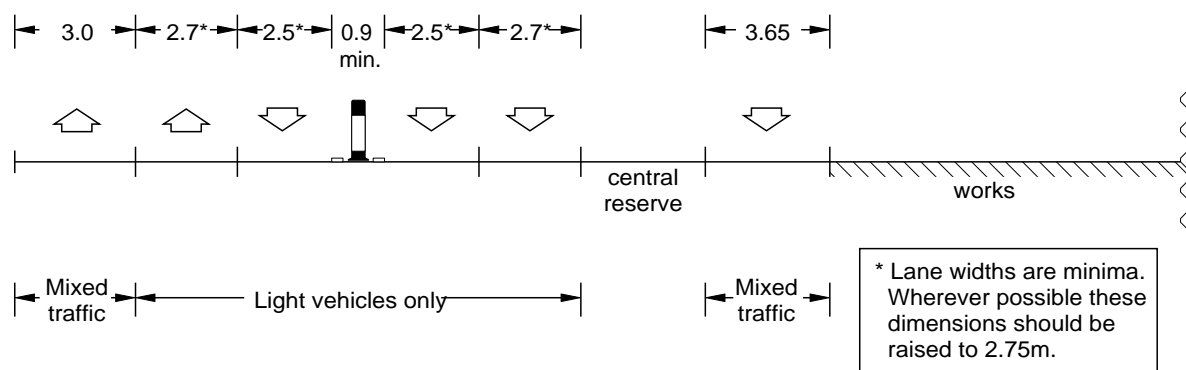
All works areas must be delineated, and with appropriate safety zones as per Chapter 8

Figure 1 SCHEMATIC AND CROSS SECTION OF NARROW LANE LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS



a) Schematic layout

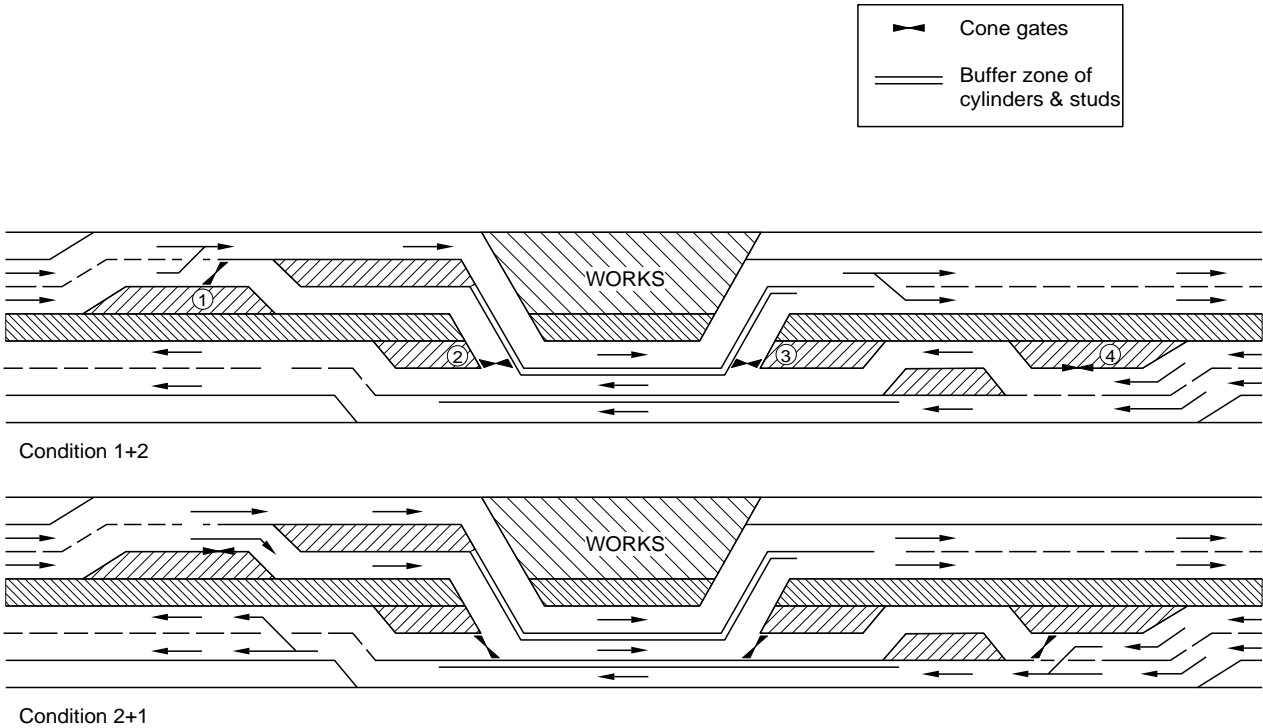
All dimensions in metres



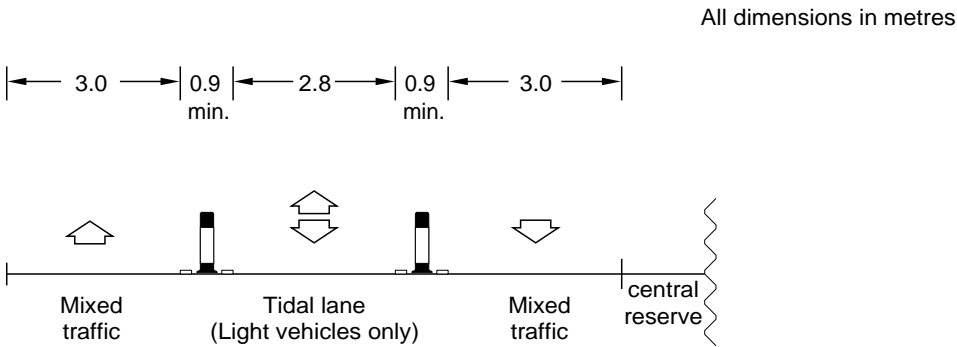
b) Carriageway cross section

All works areas must be delineated, and with appropriate safety zones as per Chapter 8

Figure 3 SCHEMATIC AND CROSS SECTION OF NARROW LANE LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS



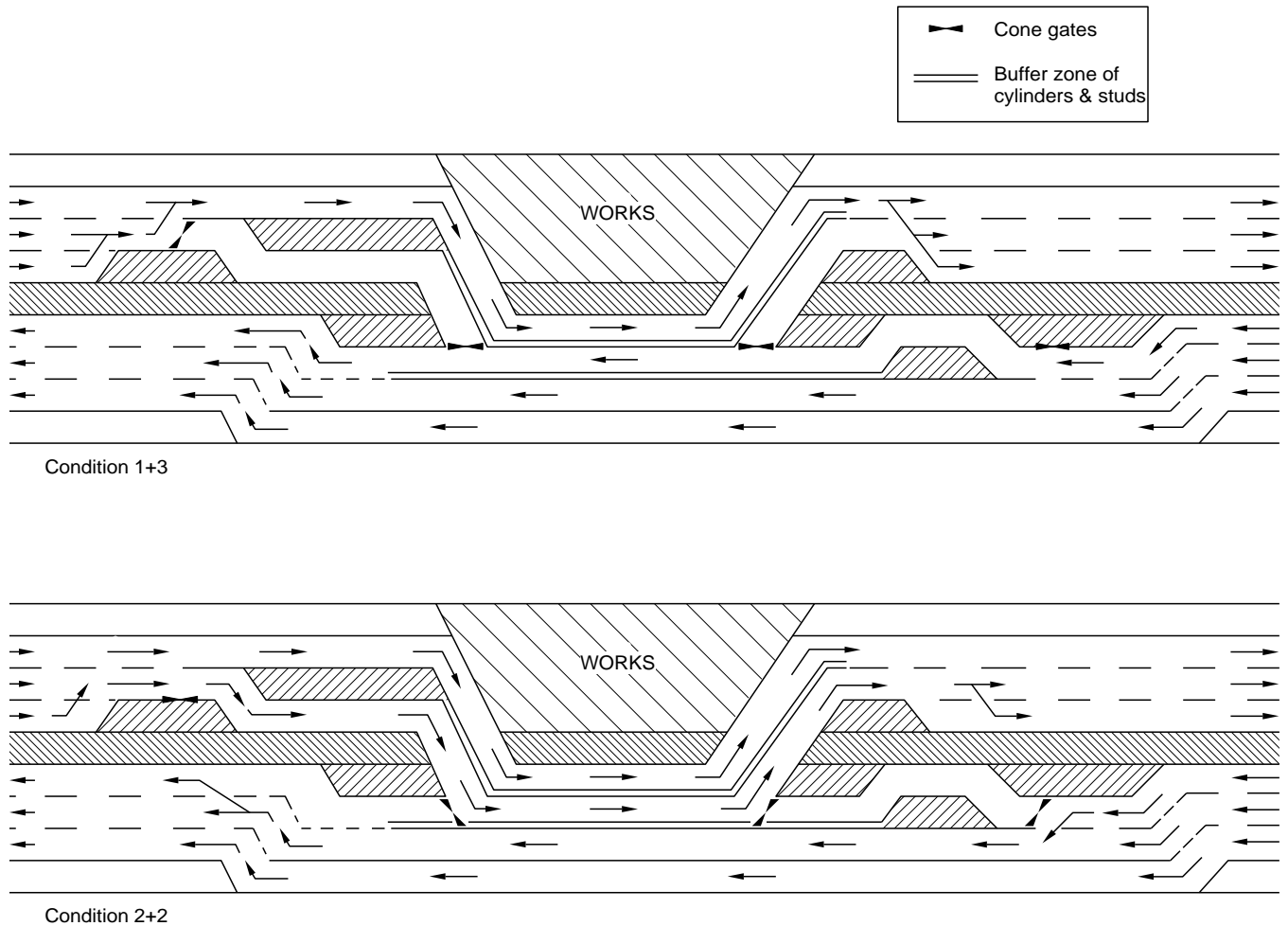
a) Schematic layout



b) Carriageway cross section

All works areas must be delineated, and with appropriate safety zones as per Chapter 8

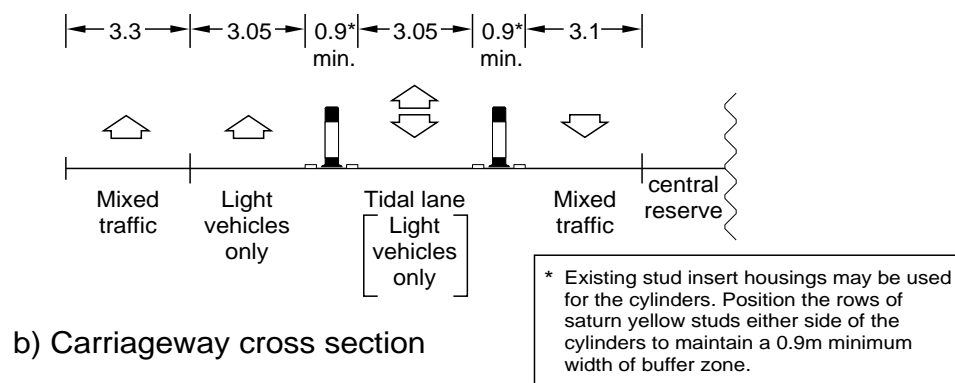
Figure 5 SCHEMATIC AND CROSS SECTION OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 2-LANE CARRIAGEWAYS



a) Schematic layout

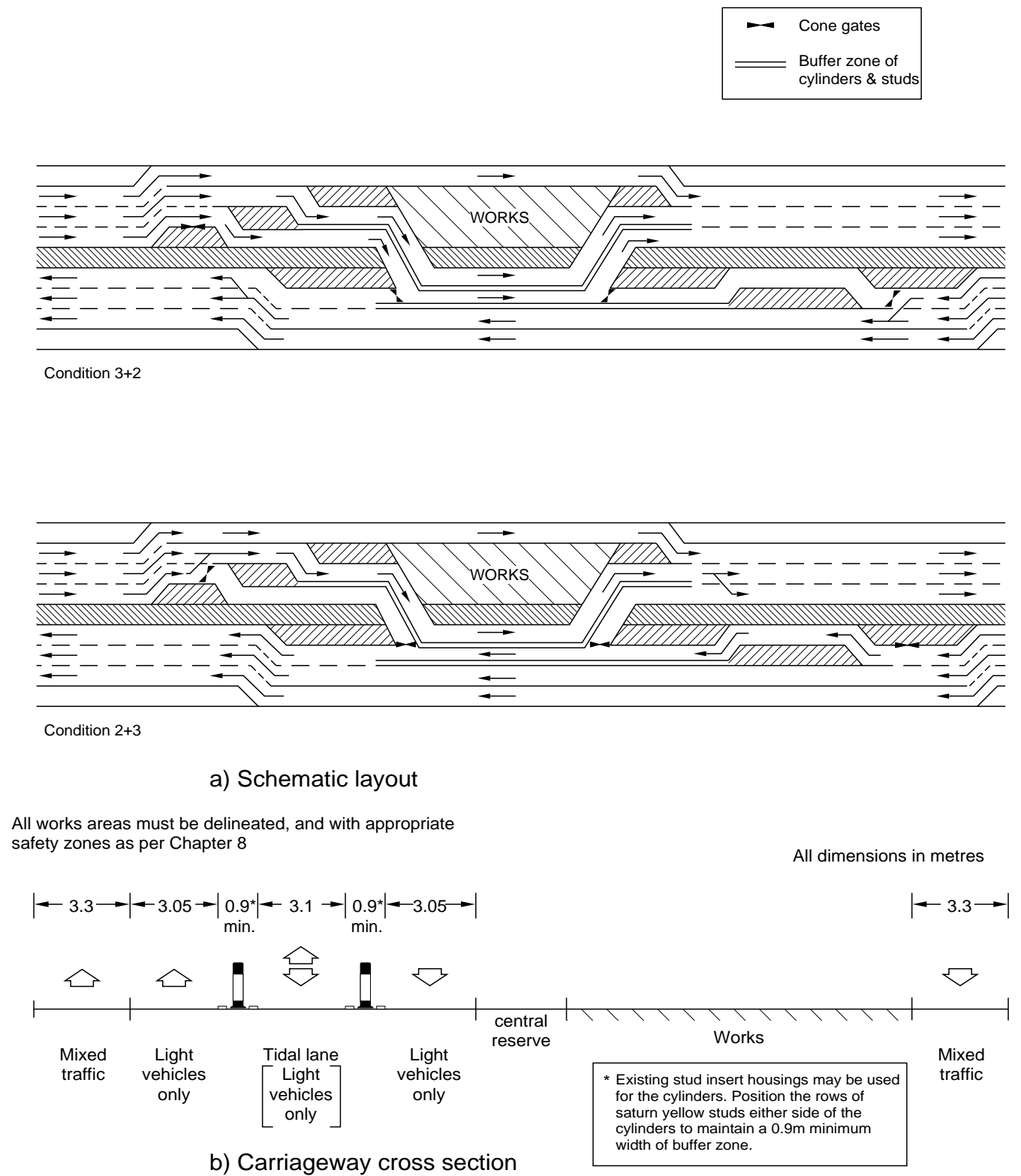
All works areas must be delineated, and with appropriate safety zones as per Chapter 8

All dimensions in metres



b) Carriageway cross section

Figure 7 SCHEMATIC AND CROSS SECTION OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS



3.3

3.05

0.9*
min.

3.1

0.9*
min.

3.05

3.3

Mixed traffic

Light vehicles only

Tidal lane
Light vehicles only

Light vehicles only

central reserve

Works

Mixed traffic

* Existing stud insert housings may be used for the cylinders. Position the rows of saturn yellow studs either side of the cylinders to maintain a 0.9m minimum width of buffer zone.

Figure 9 SCHEMATIC AND CROSS SECTION OF TIDAL FLOW LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

FIGURES 2, 4, 6, 8 & 10

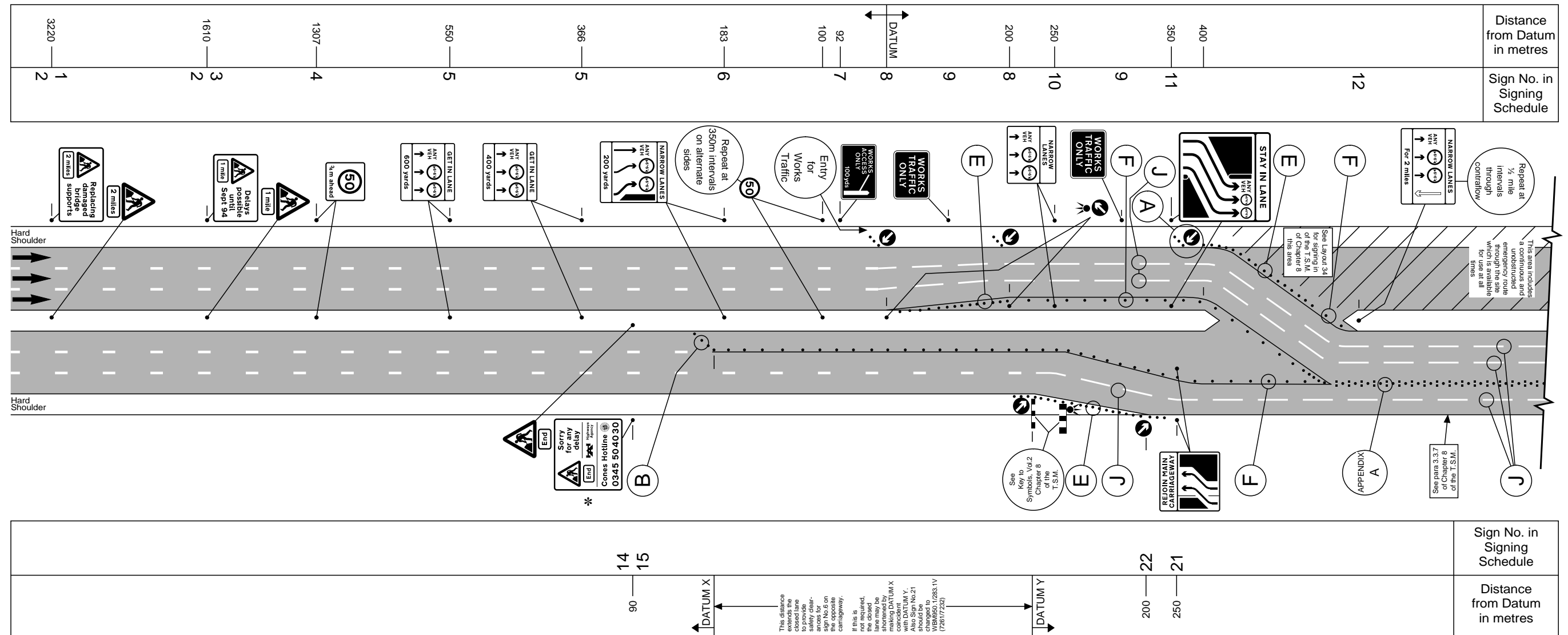
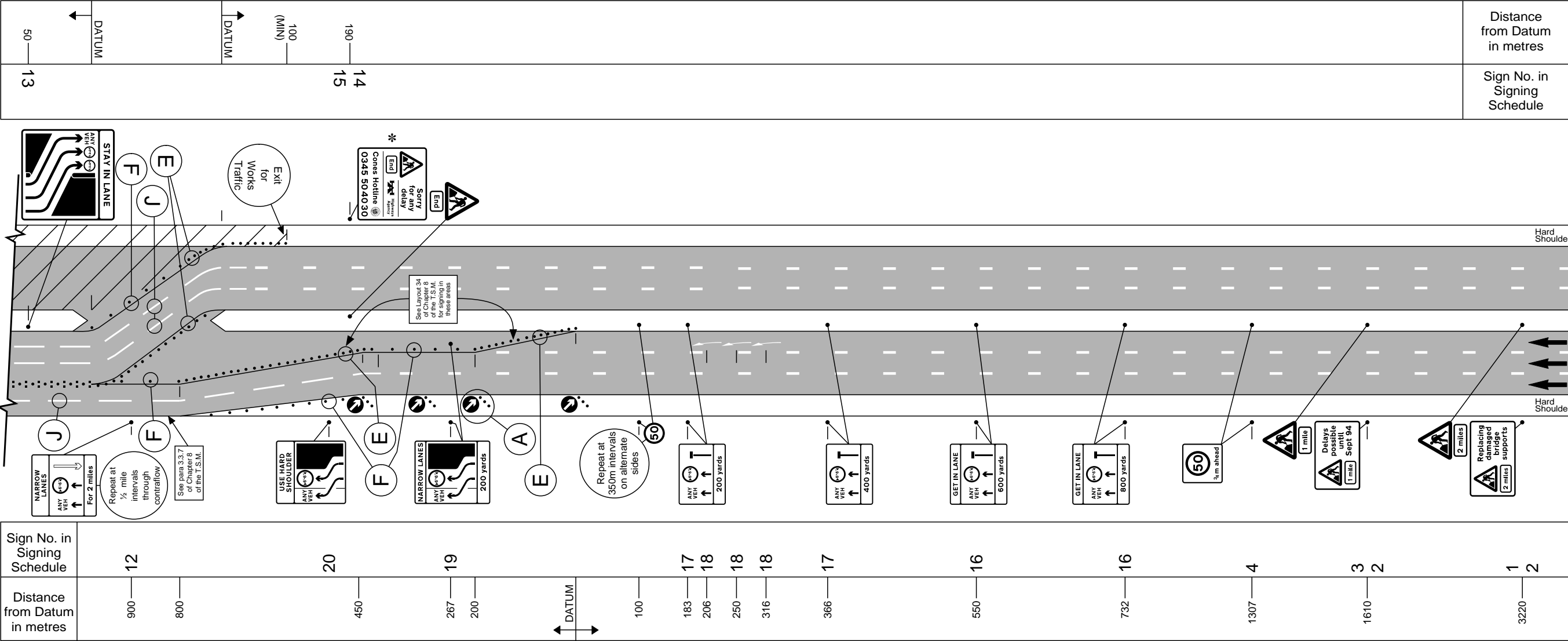


Figure 2 SIGNING OF NARROW LANE LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.



* in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

Figure 2 (continued) SIGNING OF NARROW LANE LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

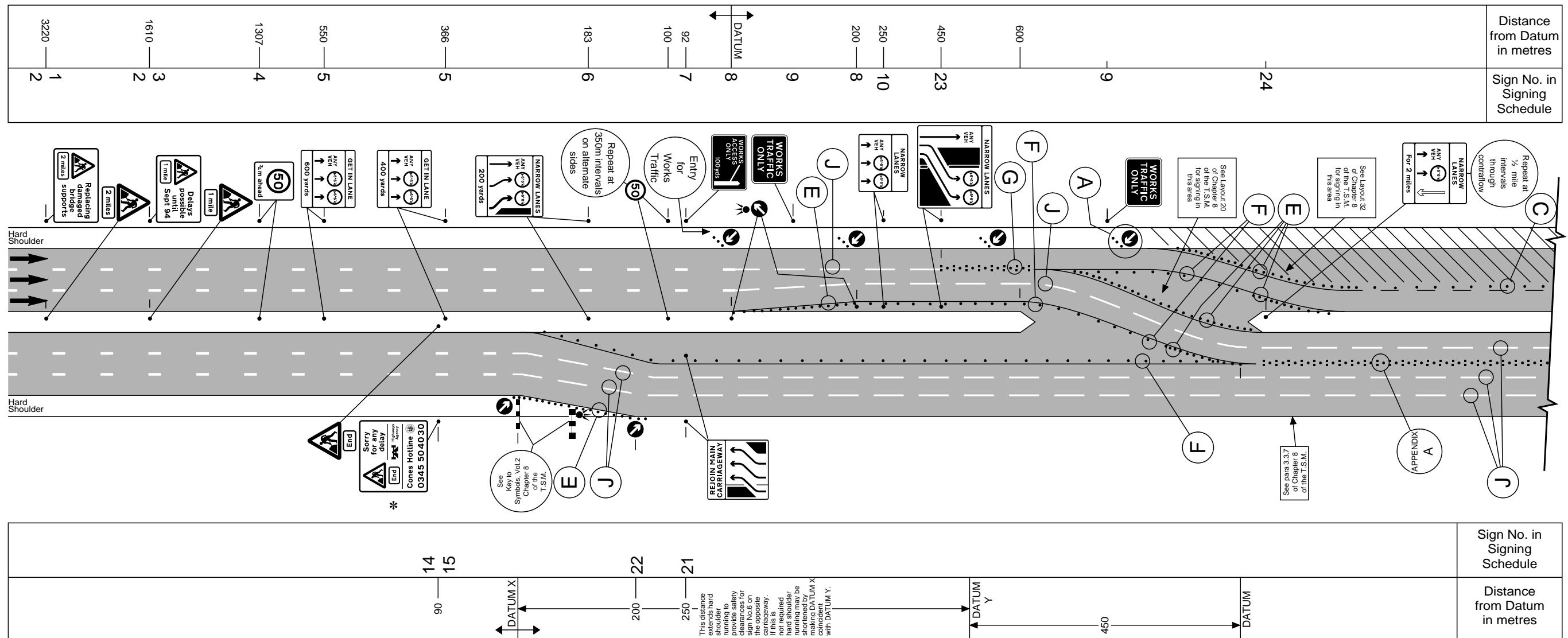
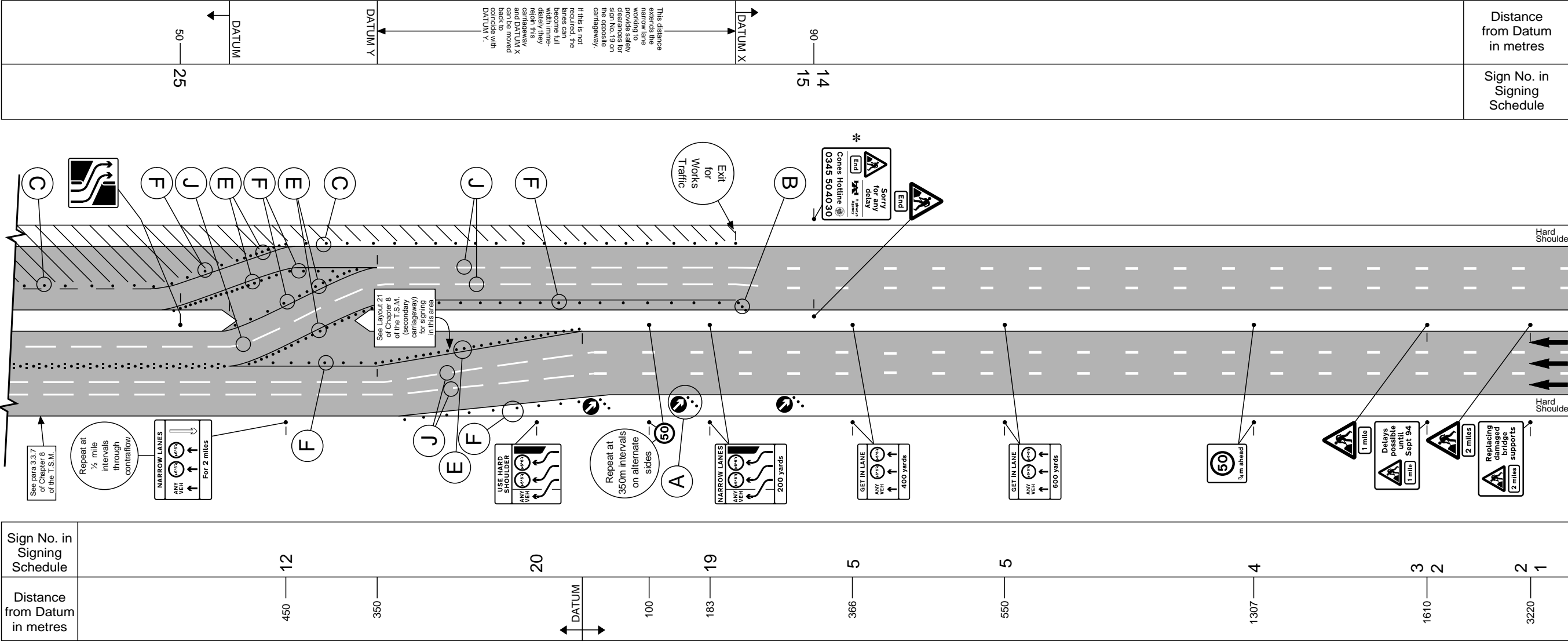


Figure 4 SIGNING OF NARROW LANE LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

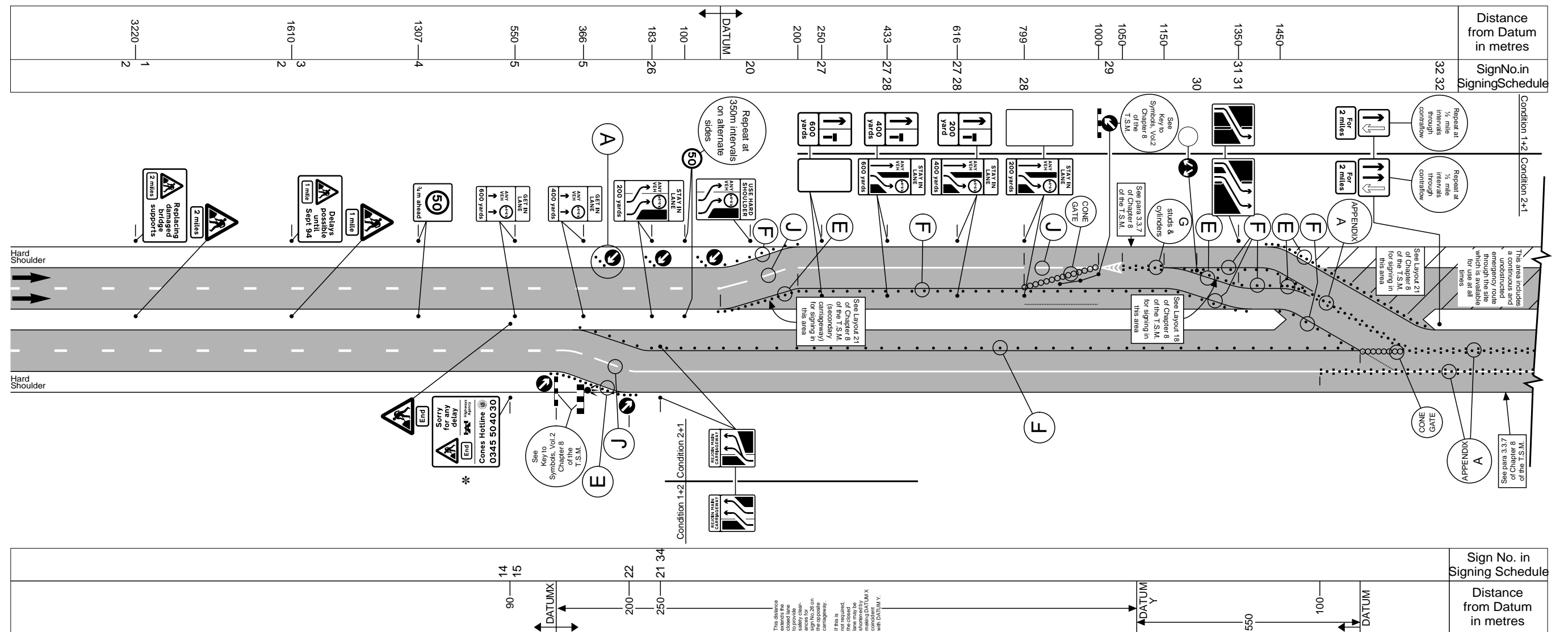
Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.



* in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

Figure 4 (continued) SIGNING OF NARROW LANE LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS



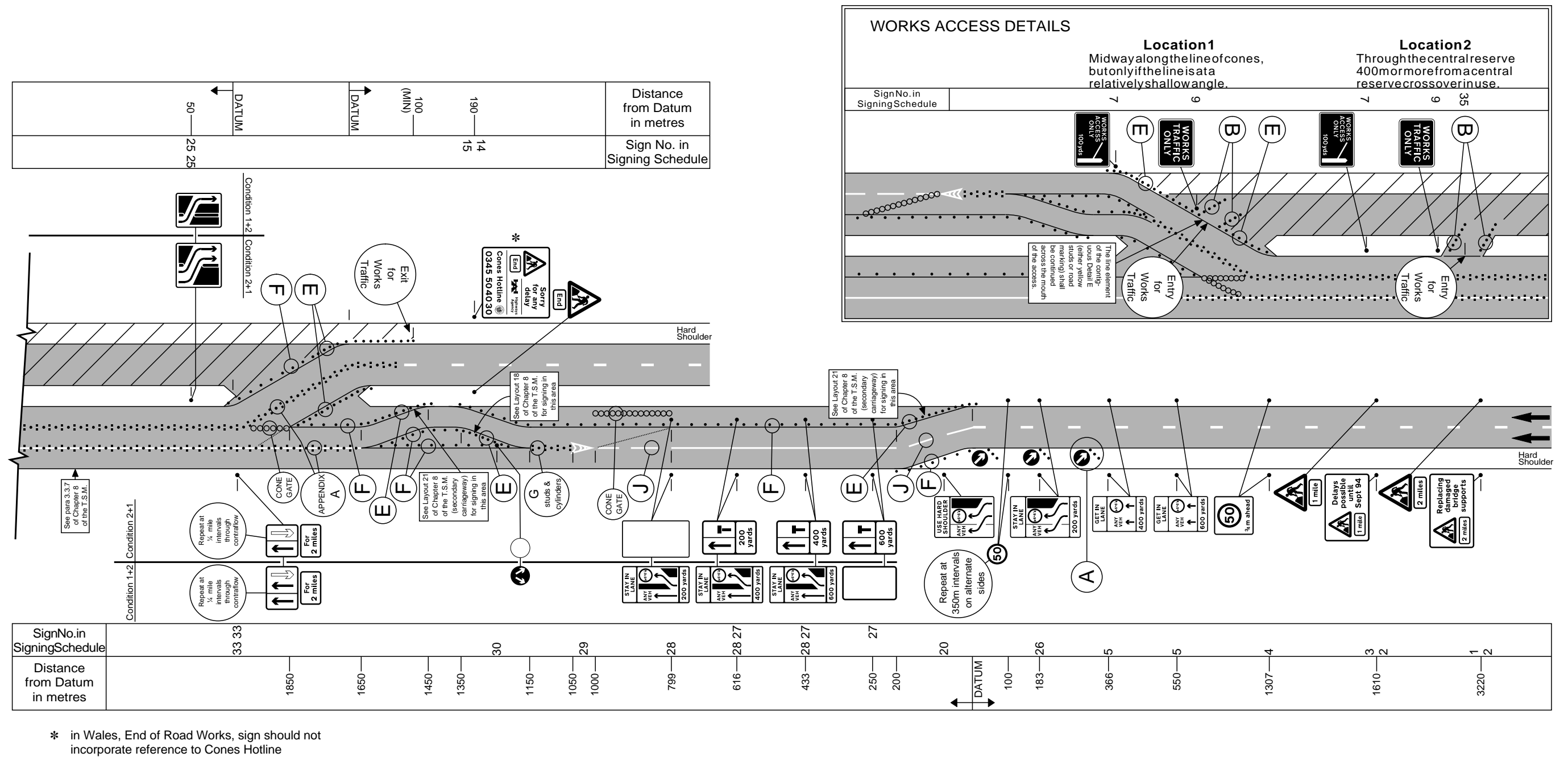
- * in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

NOTES: 1. The details of two alternative points of works access are shown in the inset on the second sheet.

2. All cone gates are shown in position for 'Condition 1+2'. Positions for 'Condition 2+1' are shown dotted.

Figure 6 SIGNING OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 2-LANE CARRIAGEWAYS

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

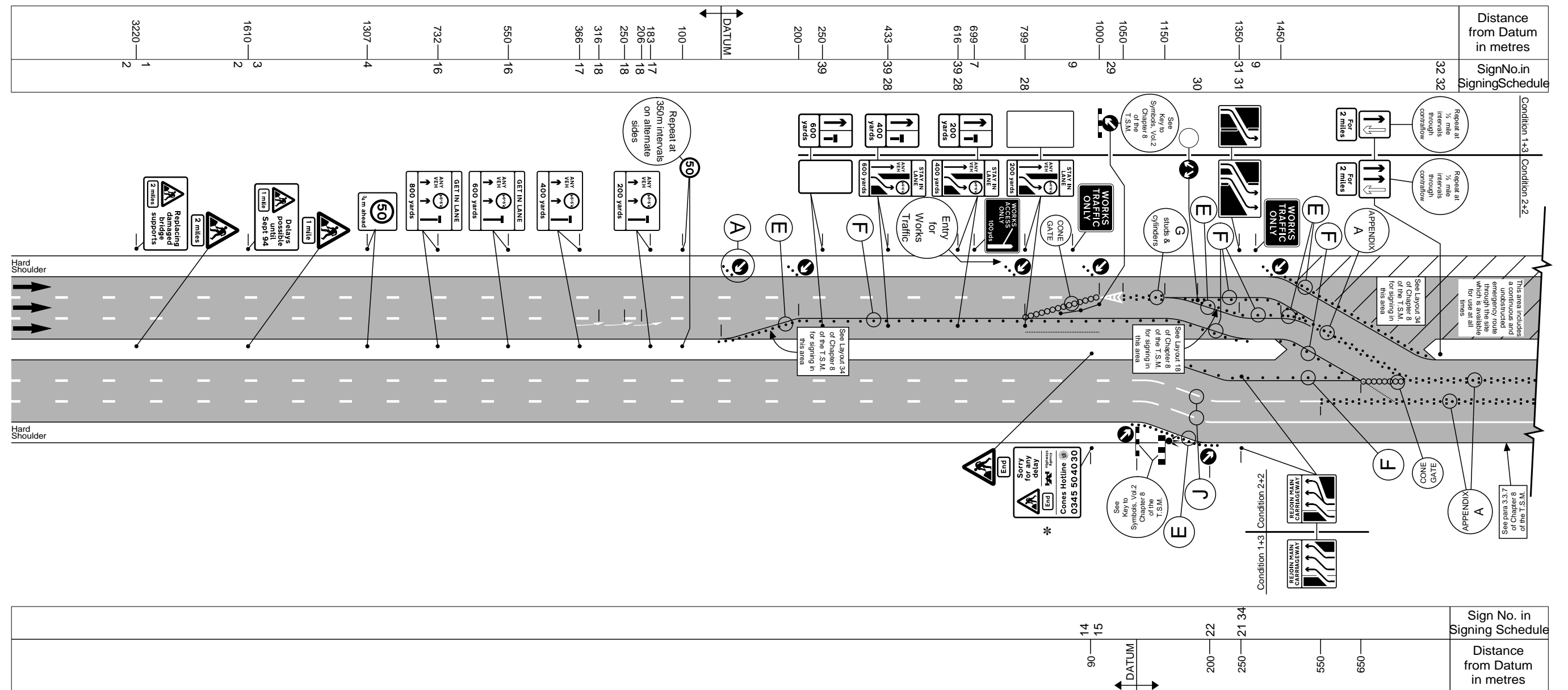


NOTES: 1. The details of two alternative points of works access are shown in the inset on the second sheet.

2. All cone gates are shown in position for 'Condition 1+2'. Positions for 'Condition 2+1' are shown dotted.

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

Figure 6 (continued) SIGNING OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 2-LANE CARRIAGEWAYS

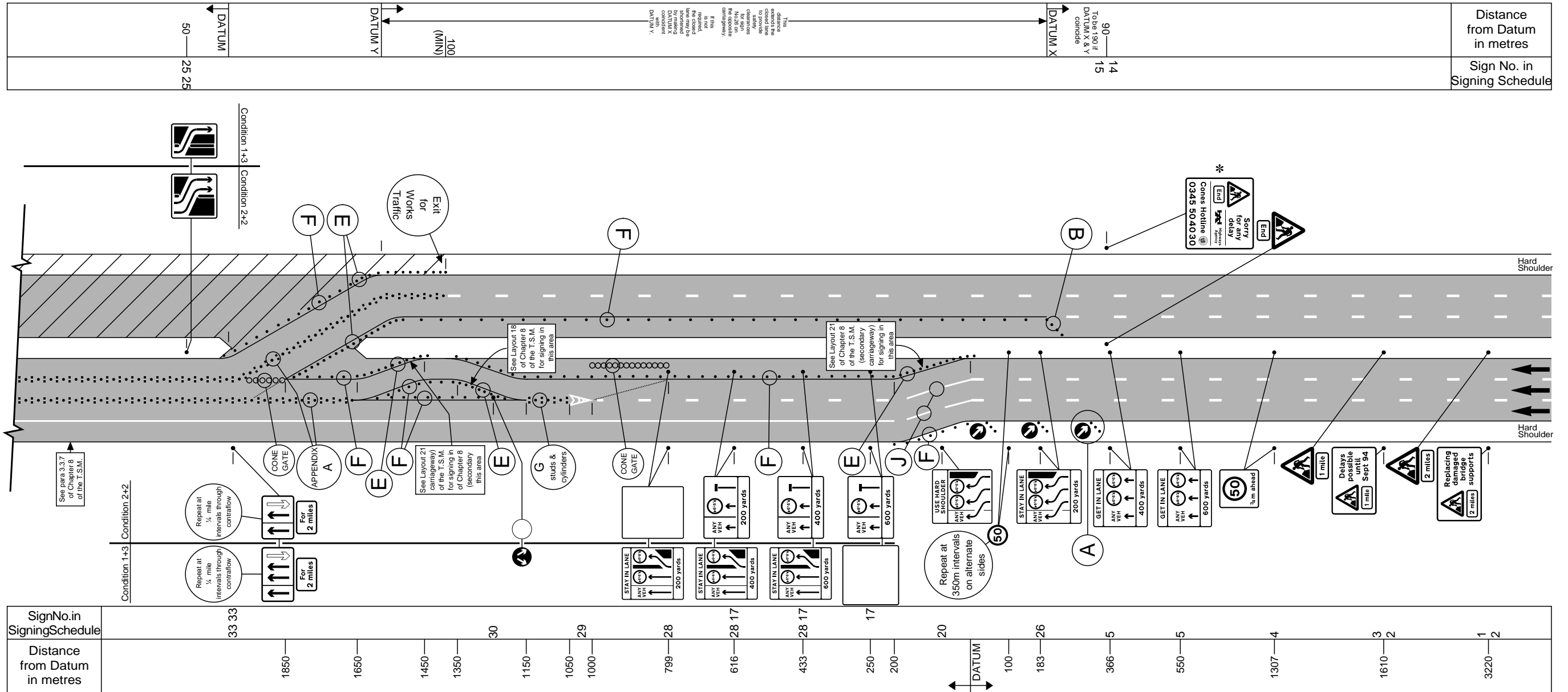


- * in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

NOTE: All cone gates are shown in position for 'Condition 1+3'.
The positions for 'Condition 2+2' are shown dotted.

Figure 8 SIGNING OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

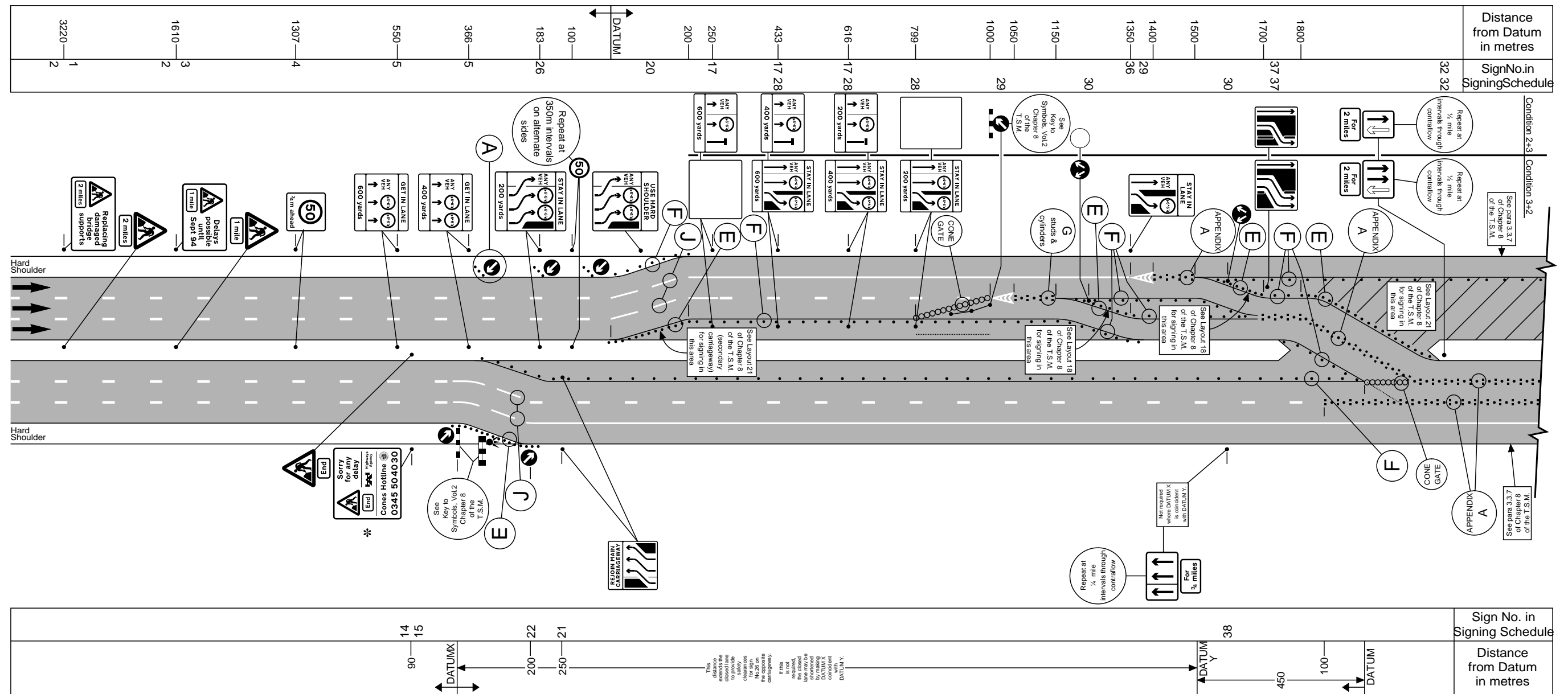


- * in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

NOTE: All cone gates are shown in position for 'Condition 1+3'.
The positions for 'Condition 2+2' are shown dotted.

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

Figure 8 (continued) SIGNING OF TIDAL FLOW LAYOUT FOR FULL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

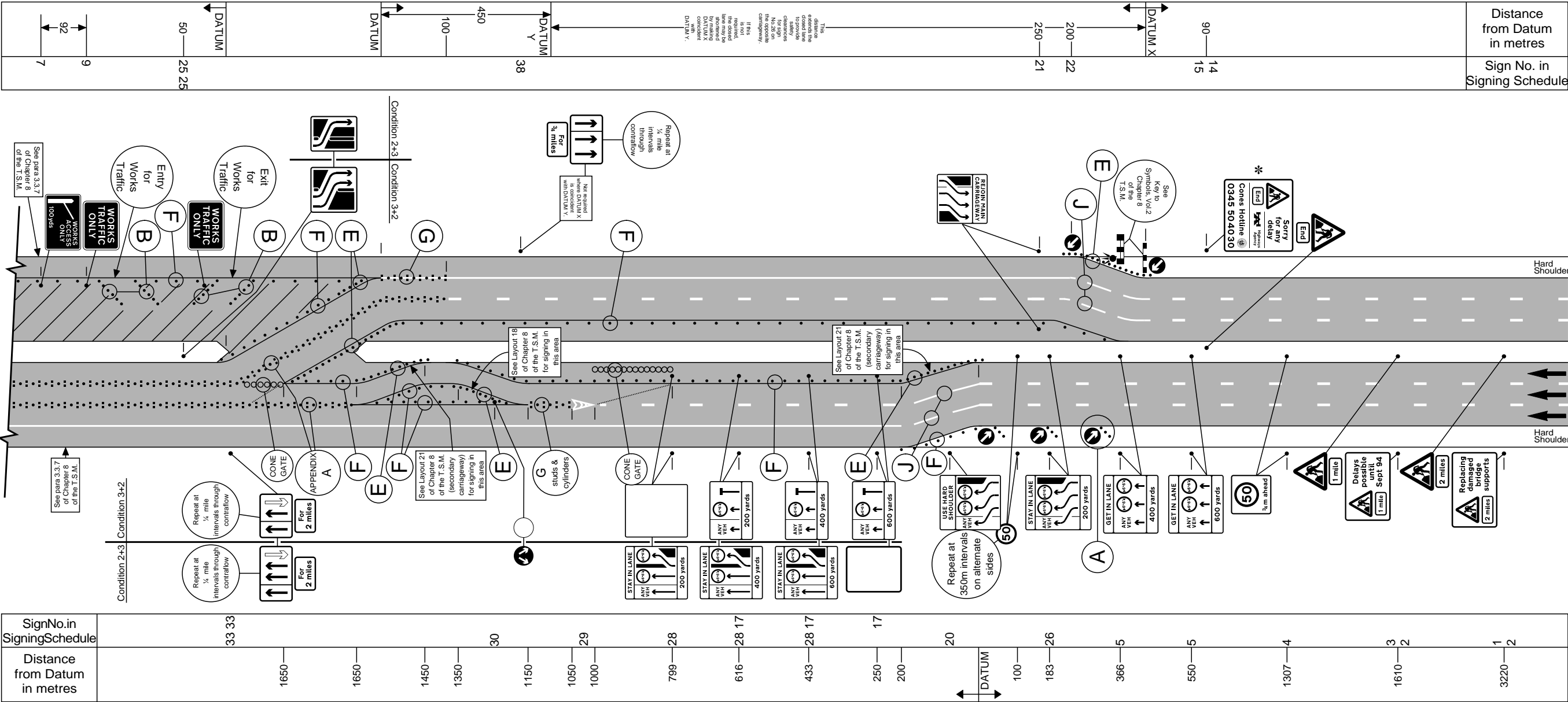


- * in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

NOTE: All cone gates are shown in position for 'Condition 2+3'.
The positions for 'Condition 3+2' are shown dotted.

Figure 10 SIGNING OF TIDAL FLOW LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.



* in Wales, End of Road Works, sign should not incorporate reference to Cones Hotline

NOTE: All cone gates are shown in position for 'Condition 2+3'.
The positions for 'Condition 3+2' are shown dotted.

Details referred to by letter are given on 'Key to Symbols' sheet in Volume 2 of Chapter 8 of the Traffic Signs Manual.

Figure 10 (continued) SIGNING OF TIDAL FLOW LAYOUT FOR PARTIAL CONTRAFLOW ON 3-LANE CARRIAGEWAYS

COST ESTIMATES OF ALTERNATIVE TRAFFIC MANAGEMENT ARRANGEMENTS

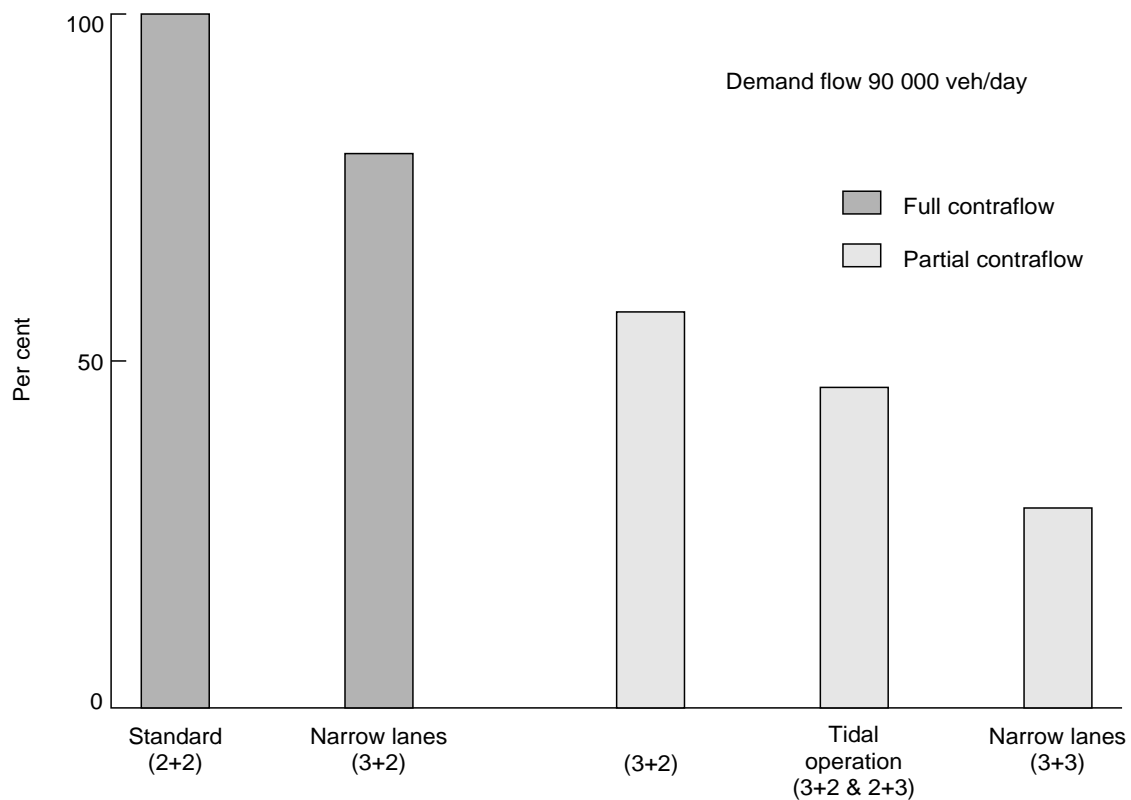


Figure 11 Cost estimates of alternative traffic management arrangements (expressed as a percentage of costs associated with the conventional [2+2] full contraflow layout)